



DINOSAUR ATLAS

An amazing journey
through a lost world

INTERACTIVE DINOSAUR CD-ROM



DINOSAUR ATLAS



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MELBOURNE, and DELHI

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Windows® PC

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The program will start automatically.

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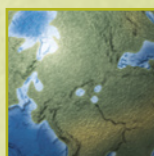
Minimum system requirements

Windows® PC
Intel Pentium® II 300MHz or higher
Windows® 98SE, 2000, ME, XP
64Mb RAM
800 x 600 16-bit color
8-speed CD-ROM drive
Windows® compatible sound card

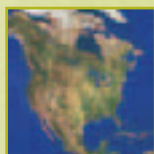
Power Macintosh Power PC processor
(G3 or higher recommended)
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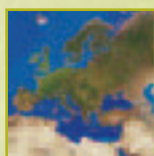
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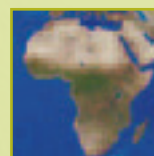
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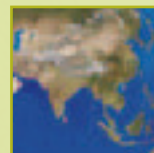
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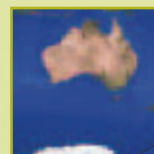
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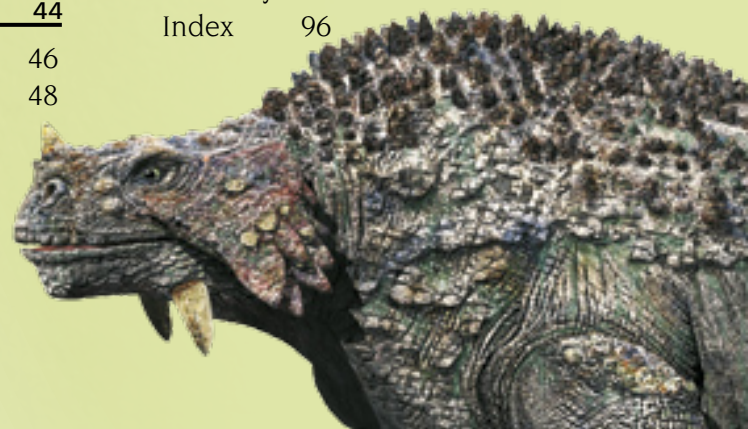
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How to use this Atlas

THIS ATLAS OF DINOSAURS can be used in several ways. The main maps show major fossil locations and list some of the prehistoric animals found there. In the pages that follow, further information is given for both the locations and the animals. Finally, if you want to find out more about dinosaurs and what happened to them, you can turn to the section at the end of the book.

SECTION OPENER PAGES ▶

The atlas has six main sections corresponding to the continents (Australia and Antarctica are treated as one). An opening map locates finds, and there are mini-profiles of dinosaurs and other prehistoric animals.

ADDITIONAL IMAGES provide further information on the topic

MAIN MAP identifies the continent, fossil locations, and prehistoric animals featured within the section



COLOR-CODED SILHOUETTES on the map locate where prehistoric animals have been found—the numbers correspond with the silhouettes in the profile list

ARTWORK SCENES ▶

In each of the six main sections, there is an artwork scene. This shows both dinosaurs and other animals of interest. It also shows the environment and what it may have been like at a certain time in prehistory.

INTRODUCTION outlines the scene's geographical location and the animals that lived there

KEY

TRIASSIC PERIOD

JURASSIC PERIOD

CRETACEOUS PERIOD

SITE

FORMATION

GLACIER

PROVINCE

COLOR KEY—the three divisions of the Mesozoic Era are color-coded, so you can see at a glance which period a dinosaur belongs to

MAP SYMBOLS show the location of fossil sites and geographical features

North America

Dinosaur fossils have been discovered at nearly 300 different locations in North America. They are found in the western interior, the southwest, and the eastern seaboard, in rocks that formed during the age of dinosaurs, from the Late Triassic to the end of the Cretaceous. Throughout these 170 million years, an unknown number of dinosaur species lived on the continent's slowly changing landscape and, so far, paleontologists have identified about 70 different kinds. They belong to all the major dinosaur groups, and several species, such as *Tyrannosaurus*, *Diplodocus*, and *Stegosaurus*, are some of the best known dinosaurs in the world.

ALASKA (USA)

CANADA

UNITED STATES OF AMERICA

MEXICO

PEACE RIVER

MORRISON FORMATION

DINOSAUR TRACKS

KEY

TRIASSIC PERIOD

JURASSIC PERIOD

CRETACEOUS PERIOD

SITE

FORMATION

ALLOSAURUS

CERATOSAURUS

DIPLODOCUS

STEGOSAURUS

ALBERTOSAURUS

CENTROSAURUS

CHINDOSAURUS

COELOPHYSIS

GOIRASAURUS

CORYTHOSAURUS

DEINONYCHUS

EDMONTONIA

EUPOLOCEPHALUS

GASTONIA

PACHYCEPHALOSAURUS

TENONTOSAURUS

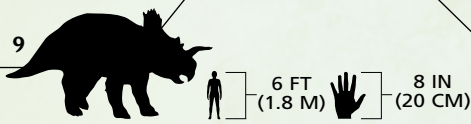
TRICERATOPS

TROODON

TYRANNOSAURUS

UTAHRAPTOR

SHOWN TO SCALE within the profile boxes are silhouettes of prehistoric animals in comparison to human dimensions



PROFILE BOXES show the prehistoric animals featured within the section, and include information on the size of the animal, a pronunciation guide, and the meaning of the scientific name

FACT BOXES throughout the book provide additional information on the topic

North America

Hell Creek

As the Missouri River flows through the east of Montana, it cuts into a series of ancient rocks known as the Hell Creek Formation. The deep layers of sandstone, siltstone, and mudstone were formed during the Late Cretaceous Period, about 65 million years ago. At that time the area was a low-lying floodplain crossed by rivers, lying along the coast of a now-vanished sea. Many species of dinosaur and other animals lived and died here. Laid down in the rocks of the Hell Creek Formation is one of the world's major dinosaur graveyards. It was here, in 1902, that the first *Tyrannosaurus* specimen was found, along with other notable discoveries.

HELL CREEK LOCATION

HELL CREEK TODAY

Barnum Brown

HELL CREEK VEGETATION

DINOSAUR TRACKS

TRICERATOPS

EDMONTONIA

MELOPACHOSAURUS

TYRANNOSAURUS

GIANT BEAVER

HELL CREEK TODAY
The soft rocks of Hell Creek have been steadily eroded by the actions of wind, water, and ice, wearing them into the deep canyons and ravines that characterize the area today. Known as "badlands," because the terrain is bad land to cross over, the dinosaur-bearing rocks lie in thick, horizontal layers. The oldest are at the bottom, and the youngest at the top.

TODAY'S LANDSCAPE information box helps the reader to compare the present-day world with that of the dinosaurs, and note any differences.



KEY

○ TOWN ● SITE

△ MOUNTAIN

GLOBAL VIEW AND SITE MAP on each spread enables you to locate the fossil site. The symbols that appear on the maps are shown above.

SEQUENCE IMAGES show how an animal is believed to have moved

BACKGROUND SCENE shows a full-color illustration of the animal as well as its habitat

DID YOU KNOW?

A bone bed has produced more than 3,000 bones belonging to perhaps 20 *Gastonia* dinosaurs. This suggests the animals lived in a herd that died in a single, sudden catastrophe.

Dinosaur tracks and eggshells are also found in the rocks.

DID YOU KNOW? boxes reveal interesting facts about a dinosaur or about a fossil site.

Gobi Desert

LOCKED INSIDE THE SANDSTONES of the Gobi Desert, Mongolia, are incredibly well-preserved dinosaur fossils of the Late Cretaceous. A stretch of rock 6 miles (10 km) long has yielded a snapshot of animal life from 75 million years ago, when the region was dry and sandy with little water. *Oviraptor* nested here, *Velociraptor* was the hunter, and herds of *Protoceratops* grazed on the low-lying ground, only to be entombed by sandstorms. Today, fossilized bones, eggs, and nests are found in the fire-red rocks of the Flaming Cliffs site.



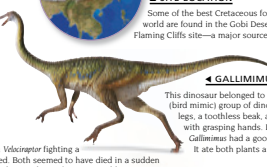
OVIRAPTOR

A carnivorous dinosaur, *Oviraptor* had a birdlike appearance. It lived in groups, and built nests in the desert sand, which it seems to have sat on to keep its eggs warm until they hatched.

Oviraptor laid clutches of 15 to 20 eggs, arranged in a circle.

VELOCIRAPTOR

At Tugrigin Us, fossils of a *Velociraptor* fighting a *Protoceratops* were discovered. Both seemed to have died in a sudden sandstorm while still locked in combat. *Velociraptor* would have been a deadly predator. It was armed with jaws that held about 80 sharp teeth, and a sickle-shaped claw on each foot for slaying its victims.



GALLIMIMUS

This dinosaur belonged to the ornithomimid (bird mimic) group of dinosaurs. It had long legs, a toothless beak, and slender arms with grasping hands. Large eyes suggest *Gallimimus* had a good sense of vision. It ate both plants and meat.

LONG, NARROW JAWS designed for biting and pulling at flesh.

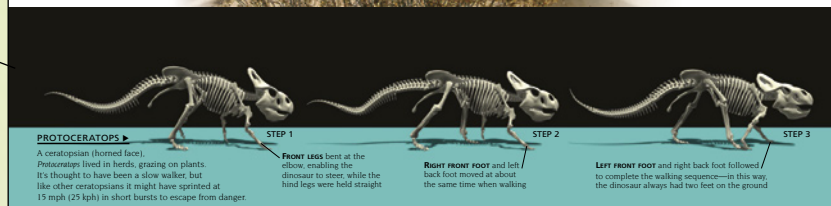
Roy Chapman Andrews



Between 1919 and 1930, Roy Chapman Andrews (1884–1960) led expeditions to the Gobi Desert where he discovered the first-known fossilized dinosaur nests, and new dinosaurs, including *Protoceratops*.

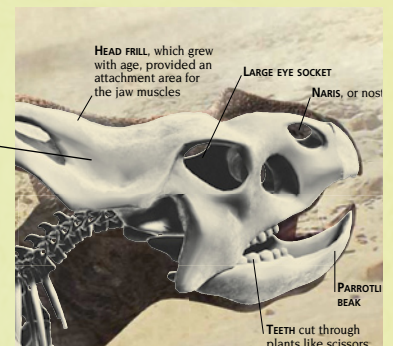
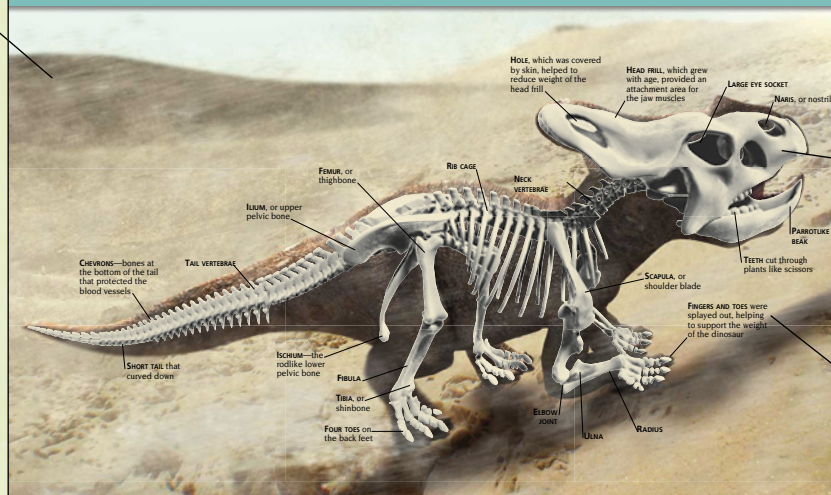
Gobi Desert

The Gobi Desert of central Asia stretches for 1,000 miles (1,600 km) across southeast Mongolia and northern China. It is an arid, inhospitable landscape, where temperatures are well below freezing at night, then become baking hot in the daytime sun.

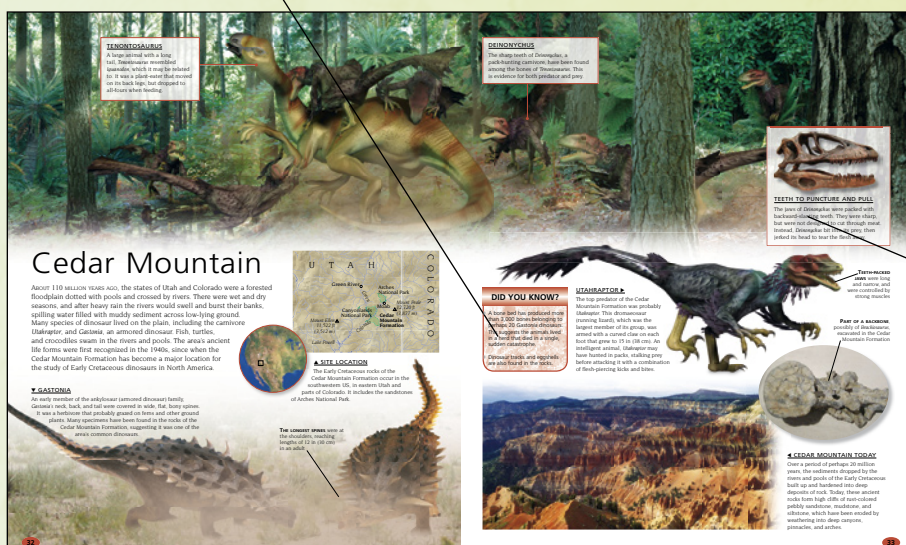


PROTOCERATOPS

A ceratopsian (horned face), *Protoceratops* lived in herds, grazing on plants. It's thought to have been a slow walker, but like other ceratopsians it might have sprinted at 15 mph (25 kph) in short bursts to escape from danger.



OVERLAY PAGE shows the skeletal framework of the animal while key features are annotated



Cedar Mountain

About 110 million years ago, the states of Utah and Colorado were a forested floodplain dotted with pools and crossed by rivers. There were wet and dry seasons, and after heavy rain the rivers would swell and burst their banks, spilling water filled with muddy sediment across low-lying ground. Many species of dinosaur lived on the plain, including the carnivore *Deinonychus* and *Gastonia*, an armored dinosaur. Fish, turtles, and crocodiles swam in the rivers and pools. The area's ancient life forms were first recognized in the 1940s, since when the Cedar Mountain Formation has become a major location for the study of Early Cretaceous dinosaurs in North America.

GASTONIA

An early member of the ankylosaurid (armored dinosaur) family, *Gastonia* had a thick, bony back and tail that were covered in scutes, that bony plates. It was a herbivore that probably grazed on ferns and other ground plants. Many specimens have been found in the rocks of the Cedar Mountain Formation, suggesting a herd of these animals common dinosaurs.

THE LARGEST DINO seen at the site is the ankylosaur, reaching lengths of 12 to 15 meters in an adult.

SITE LOCATION

The Early Cretaceous rocks of the Cedar Mountain Formation occur in the southern Utah, in eastern Utah and north of Colorado. It includes the sandstones of Archelus National Park.

DEINONYCHUS

The sharp teeth of *Deinonychus*, a meat-eating dinosaur, have been found among the bones of *Triceratops*. This evidence for flesh-eating and prey.

A herd of *Deinonychus* has been found in the rocks of the Cedar Mountain Formation. It is thought that there is a single, sudden catastrophe.

Deinonychus had a sickle-shaped claw on each foot for slaying its victims.

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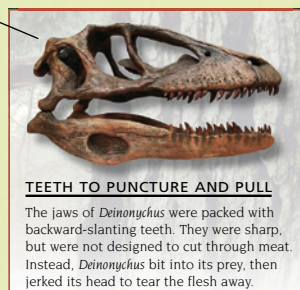
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MAIN SECTION

These pages detail selected fossil sites from the given continent, and the prehistoric animals that lived in these areas. They include world-famous locations, noted for their abundance of fossils, or because finds have been made there that have greatly increased our knowledge.



PHOTOGRAPHS throughout the book show actual specimens, and text captions draw attention to the key features.

Life on Earth

THE GIANT REPTILES OF THE DINOSAUR AGE were among the most spectacular products of evolution, the process that has formed all living things. The process began in the sea over 3,500 million years ago, when a number of chemicals became linked together in a complex compound that was able to make copies of itself. In other words, it became alive. The chances of this happening are so slim that it may have occurred just once in the history of the universe. Yet it did happen and, once a living organism existed, it was able to multiply, evolve, and give rise to the wonderful diversity of life on Earth.

SPARK OF LIFE ►

All life is based on deoxyribonucleic acid, or DNA (an extremely complex substance that controls growth and reproduction). For life to begin, DNA—or something like it—must have been created from a series of reactions between simple ingredients like the nitrogen, methane, sulfide, and water vapor that formed part of the early atmosphere. The energy needed to trigger the reactions could have been provided by lightning—the original spark of life.



◀ LIVING CELLS

The first living things probably resembled bacteria, the simplest organisms found on Earth today. Each bacterium is a microscopic satchel of fluid containing sugars, fats, proteins, and DNA, enclosed within a cell membrane. It can feed, grow, and replicate itself. Over millions of years, similar cells developed ways of working together to build the complex multicellular organisms that evolved into plants and animals.

THESE TWO BACTERIA are among the simplest of all life forms, but they are far more complicated than any nonliving things

DISTANT ANCESTORS ►

The earliest traces of life have been found in Australia, in rocks that are 3,500 million years old. They are the fossilized remains of stromatolites—colonies of single-celled cyanobacteria. These are bacteria that make food from water and carbon dioxide by photosynthesis, just as green plants do. They were the only form of life on Earth for nearly 3 billion years, and the ancestors of all other living things.

STROMATOLITES still thrive in Shark Bay, Western Australia, creating a scene that could have existed 3 billion years ago

TIME CHART

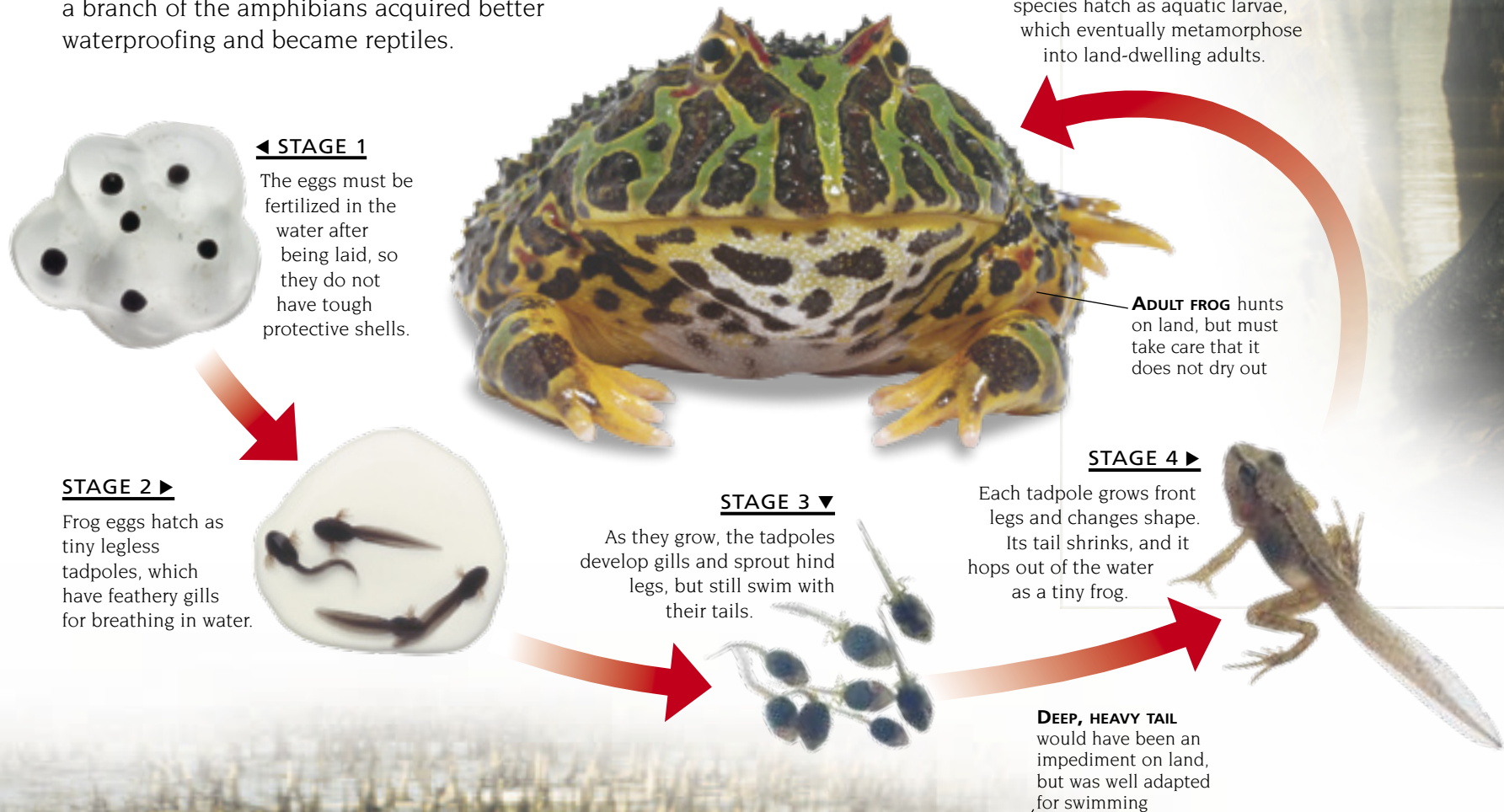
CENOZOIC 65-0 MYA	► Pleistocene: A period of ice ages, when large areas are covered by ice sheets. These are interspersed with subtropical interglacials. A warmer phase of the current ice age sees the rise of humans, and a mass extinction of large mammals such as the camel-like <i>Macrauchenia</i>.	MYA ► 2 MACRAUCHENIA 
	► Pliocene: North and South America become linked, allowing animals to migrate between the two. The first bipedal hominids evolve in Africa, and eventually give rise to early humans such as <i>Homo habilis</i>.	► 5 HOMO HABILIS 
	► Miocene: The Antarctic icecap forms, lowering sea levels. The climate becomes cooler, encouraging the expansion of grasslands and the evolution of specialized grazing mammals.	► 23 GOMPHOTHERIUM 
	► Oligocene: Mammals similar to modern forms appear. Some are giant "megaherbivores" like <i>Paraceratherium</i>, a type of rhinoceros that stood 20 ft (6 m) high at the shoulders and browsed tree foliage.	► 34 PARACERATHERIUM 
	► Eocene: Plant-eating and hunting mammals become established as the dominant animals on land. Many are still quite small, like the dog-sized <i>Phenacodus</i>, an early hoofed mammal.	► 55 PHENACODUS 
MESOZOIC 251-65 MYA	► Paleocene: The first epoch of the Tertiary Period sees the rise of giant, predatory land birds. Surviving reptiles flourish in the warm climate, and mammals begin to diversify. The first bat appears.	► 65 ICARONYCTERIS 
	► Cretaceous: Dinosaurs flourish on land until the last of them are wiped out by a mass extinction at the end of the period. The first flowering plants evolve, and small mammals become widespread.	► 145 DEINONYCHUS 
	► Jurassic: Dinosaurs, flying pterosaurs, and marine reptiles diversify into many forms, including giant plant-eating sauropods like <i>Camarasaurus</i> and bipedal, carnivorous theropods.	► 200 CAMARASAURUS 
	► Triassic: The first period of the Mesozoic Era is marked by warm, wet climates that gradually become hotter and drier. The first dinosaurs such as <i>Coelophysis</i> appear, and the first mammals.	► 251 COELOPHYSIS 
PALEOZOIC 542-251 MYA	► Permian: The last period of the Paleozoic sees the formation of the giant supercontinent Pangaea, the development of vast deserts, and a mass extinction of animals at the end of the period.	► 299 SCUTOSAURUS 
	► Carboniferous: Tropical conditions almost worldwide lead to the growth of lush fern forests that become fossilized as coal. The first reptiles evolve and spread rapidly over the land.	► 359 HYLONOMUS 
	► Devonian: Green plants spread over the land, and trees and insects appear. Many forms of fish evolve, and the earliest four-legged amphibians such as <i>Acanthostega</i> colonize the land.	► 416 ACANTHOSTEGA 
	► Silurian: The first jawed fish, such as <i>Climatius</i>, appear in the oceans. True land plants appear, and primitive invertebrate land animals such as centipedes develop toward the end of the period.	► 444 CLIMATIUS 
	► Ordovician: Strange relatives of starfish such as <i>Cothurnocystis</i> evolve in the oceans, and the earliest jawless fish appear. The first primitive green plants start to grow on land.	► 488 COTHURNOCYSTIS 
PRECAMBRIAN 4,567-542 MYA	► Cambrian: The first period of the Palaeozoic Era sees an "explosion" of multicellular life in the oceans, including the appearance of the trilobites, which resemble modern sea slaters.	► 542 TRILOBITE 
	► Precambrian: Over most of Precambrian time—80 percent of Earth's history—the only life forms are bacteria, which appear about 3,500 million years ago. Multicelled marine animals like <i>Spriggina</i> appear at the end of the era.	► 4,567 SPRIGGINA 

Rise of the Reptiles

COMPLEX, MULTICELLULAR LIFE evolved in the oceans, some 3 billion years after the appearance of the first bacteria. Invertebrates resembling modern sea squirts eventually gave rise to primitive fish, which had bodies supported by internal skeletons. During the Late Devonian Period, some 370 million years ago, some fish developed simple lungs and limblike fins that enabled them to crawl out of the water onto land. They evolved into amphibians—thin-skinned animals such as salamanders and frogs that live in moist places and breed in water. About 290 million years ago, a branch of the amphibians acquired better waterproofing and became reptiles.

▼ AMPHIBIAN LIFE CYCLE

Amphibians such as frogs have thin, delicate skins that must be kept moist. They spawn like fish, laying jelly-covered eggs in water or damp places, and fertilizing them externally. The eggs of most species hatch as aquatic larvae, which eventually metamorphose into land-dwelling adults.

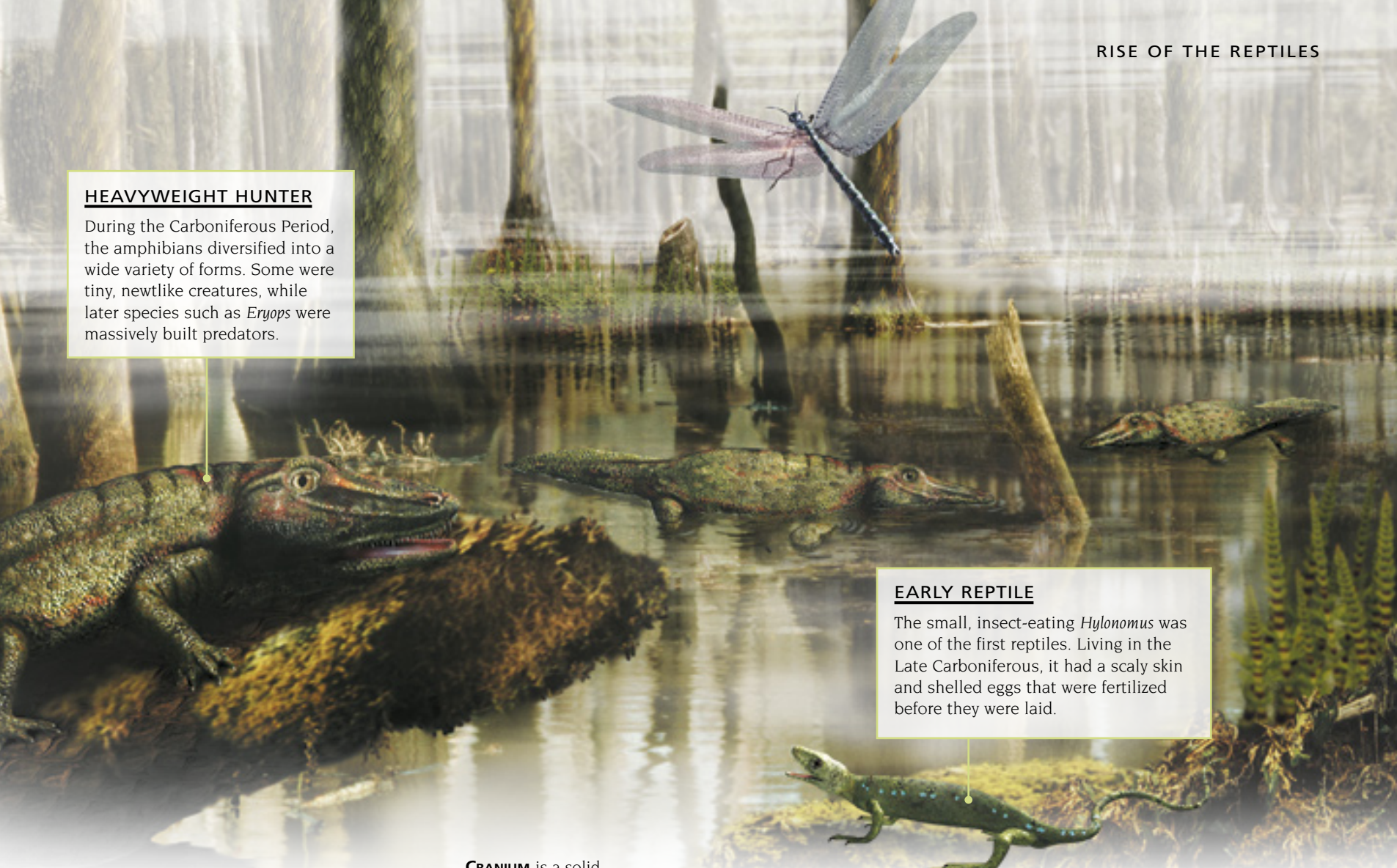


▼ AMPHIBIAN PIONEER

An early four-legged amphibian, *Acanthostega* was about 2 ft (60 cm) long, with a flattened body and a long tail. It seems to have lived rather like a modern crocodile, feeding largely on fish in the water, but its strong vertebrate skeleton would have enabled it to roam freely through the Devonian swamps.

HEAVYWEIGHT HUNTER

During the Carboniferous Period, the amphibians diversified into a wide variety of forms. Some were tiny, newtlike creatures, while later species such as *Eryops* were massively built predators.

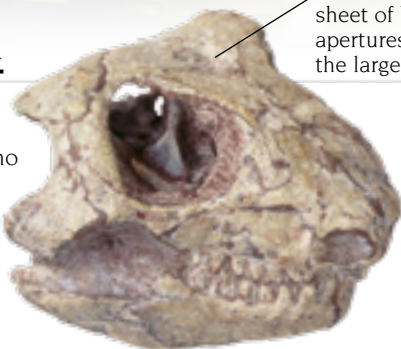


EARLY REPTILE

The small, insect-eating *Hylonomus* was one of the first reptiles. Living in the Late Carboniferous, it had a scaly skin and shelled eggs that were fertilized before they were laid.

ANAPSID SKULL ▶

Early reptiles like *Hylonomus* had simple “anapsid” skulls with no extra openings to provide anchorage for strong jaw muscles. Tortoises have the same skull type.



CRANIUM is a solid sheet of bone, with no apertures aside from the large eye sockets

▼ MODERN REPTILE

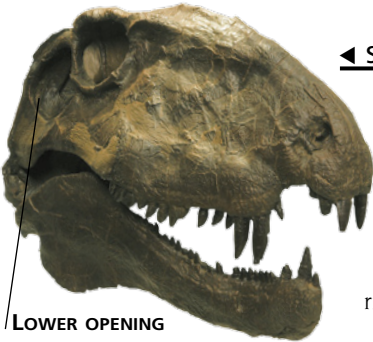
In the 290 million years since they first appeared, reptiles have evolved a variety of forms. The most recent of these are the snakes—dedicated hunters that are particularly successful in tropical climates.



LEGLESS, SERPENTINE BODY FORM of a snake is surprisingly efficient

◀ SYNAPSID SKULL

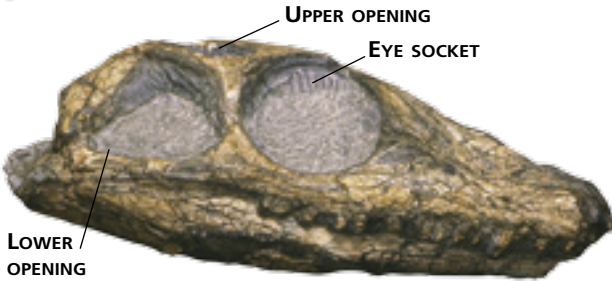
From the Late Carboniferous Period, reptiles started developing “synapsid” skulls with arched openings behind the eye sockets. These enabled the jaw muscles to be attached more securely, giving a more powerful bite. Such synapsid reptiles eventually gave rise to the mammals.



LOWER OPENING

DIAPSID SKULL ▶

The diapsid reptiles had two skull openings behind each eye socket. They included a variety of lizardlike animals, and eventually the dinosaurs, pterosaurs, crocodiles, and birds.



LOWER OPENING

UPPER OPENING
EYE SOCKET

AMNIOTIC EGG ▶

Enclosed by a tough, waterproof shell, a reptile egg can be laid on dry land, and hatches as a miniature adult instead of an aquatic larva. This is a fossilized egg of the carnivorous dinosaur *Troodon*, showing the unhatched animal inside.



Triassic World

THE PALEOZOIC ERA ended with a mass extinction that seems to have wiped out 70 percent of life on Earth. It took the Triassic world about 10 million years to recover from the catastrophe, and by that time the surviving reptiles were evolving into new forms. They included the therapsids, mammal-like reptiles that gave rise to the first true mammals at the end of the Triassic. They also included marine reptiles, such as the nothosaurs and ichthyosaurs, the first of the flying pterosaurs, and—appearing some 230 million years ago—the earliest dinosaurs.

◀ PLACERIAS

This powerful, tusked animal was one of the larger mammal-like reptiles. These ancestors of the mammals disappeared at the end of the Triassic Period.

TRIASSIC GLOBE ▶

During the Triassic, all the continents were joined into a single landmass called Pangaea.

The heartlands of this supercontinent were so far from the ocean that they were parched deserts, but nearer the fringes there were lush, swampy forests.

LARIOSAUROS ▶

One of the aquatic nothosaurs, *Lariosaurus* lived in shallow seas about 230 million years ago. It probably swam somewhat like an otter, but far less efficiently.

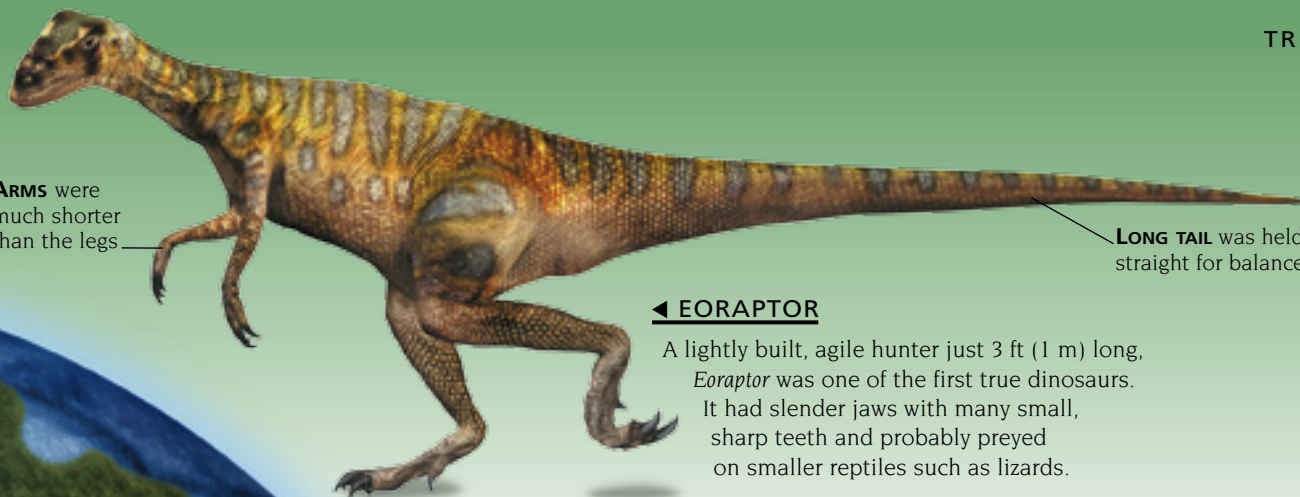
◀ EUDIMORPHODON

The first flying pterosaurs appeared in the Late Triassic Period. They had leathery wings supported by a greatly extended fourth finger and long, bony tails. Early species were quite small, and *Eudimorphodon* was just 28 in (70 cm) long.

◀ FERNS

There were no flowering plants in the Triassic and no grasses. The undergrowth was dominated by more primitive green plants, such as ferns and horsetails, which were eaten by herbivorous animals like *Placérias*.

ARMS were much shorter than the legs

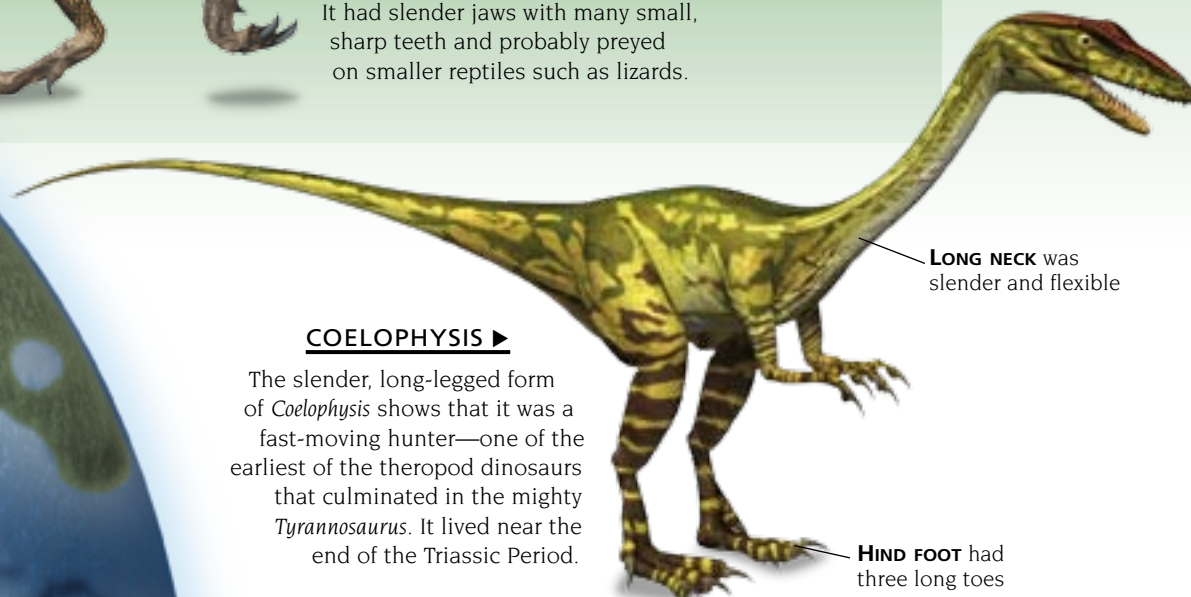


LONG TAIL was held straight for balance

◀ EORAPTOR

A lightly built, agile hunter just 3 ft (1 m) long, *Eoraptor* was one of the first true dinosaurs. It had slender jaws with many small, sharp teeth and probably preyed on smaller reptiles such as lizards.

LONG NECK was slender and flexible



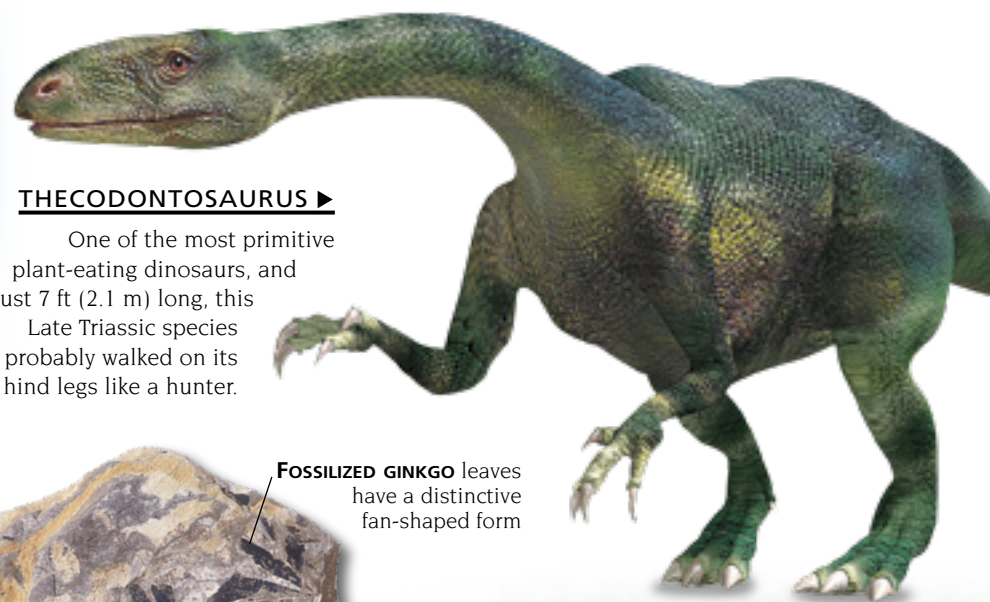
COELOPHYSIS ▶

The slender, long-legged form of *Coelophysis* shows that it was a fast-moving hunter—one of the earliest of the theropod dinosaurs that culminated in the mighty *Tyrannosaurus*. It lived near the end of the Triassic Period.

HIND FOOT had three long toes

THECODONTOSAURUS ▶

One of the most primitive plant-eating dinosaurs, and just 7 ft (2.1 m) long, this Late Triassic species probably walked on its hind legs like a hunter.



FOSSILIZED GINKGO leaves have a distinctive fan-shaped form



GINKGO ▶

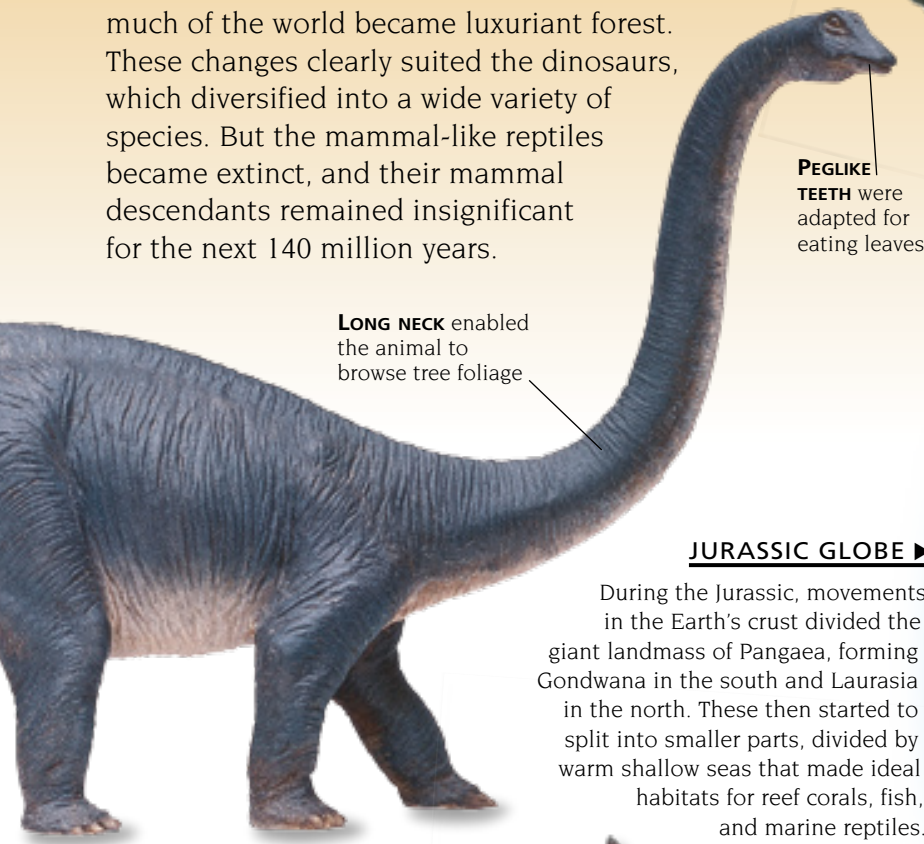
Triassic forests consisted of cycads, conifers, and other primitive trees like the ginkgo. These plants still thrive today, and the fan-shaped leaves of modern ginkgos are little changed from those in Triassic fossils.

THE CONTINENTS are in different places today



Jurassic World

THE JURASSIC PERIOD was a time of climate change, brought about by the breakup of the huge, dry supercontinent Pangaea into two smaller landmasses, and the creation of many shallow seas. Global temperatures were still warm because there were no polar ice sheets, but there was more rainfall. Desert areas shrank as a result, and much of the world became luxuriant forest. These changes clearly suited the dinosaurs, which diversified into a wide variety of species. But the mammal-like reptiles became extinct, and their mammal descendants remained insignificant for the next 140 million years.



LONG NECK enabled the animal to browse tree foliage

PEGLIKE TEETH were adapted for eating leaves

JURASSIC GLOBE ►

During the Jurassic, movements in the Earth's crust divided the giant landmass of Pangaea, forming Gondwana in the south and Laurasia in the north. These then started to split into smaller parts, divided by warm shallow seas that made ideal habitats for reef corals, fish, and marine reptiles.

▲ DIPLODOCUS

The Jurassic was the age of giant plant-eating sauropods like *Diplodocus*, which grew to at least 89 ft (27 m) long. These immense animals probably lived in herds, like modern elephants.

ICHTHYOSAURUS ▲

Fast-swimming, dolphinlike reptiles called ichthyosaurs flourished in the warm, shallow seas, where they used their small, sharp teeth to catch fish.

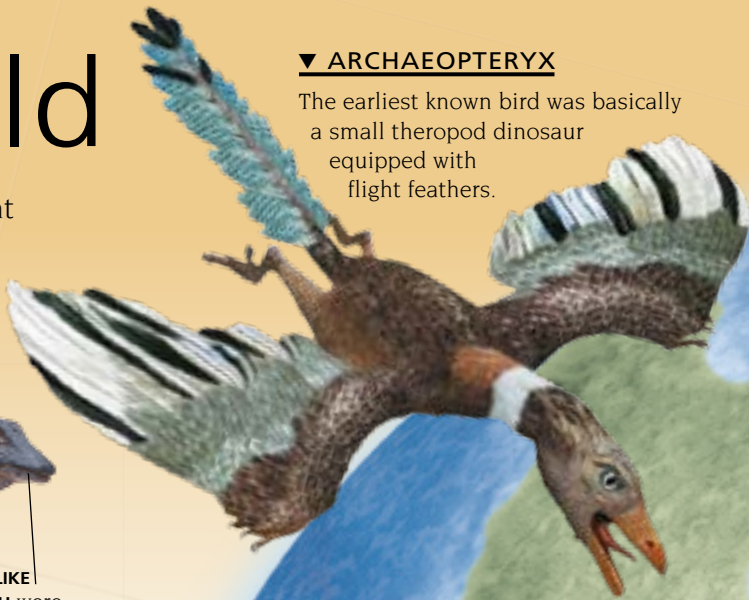
◀ JURASSIC TREES

Forests covered vast areas of land. They were made up of coniferous trees such as monkey puzzles, as well as ginkgos, tree ferns, and cycads.

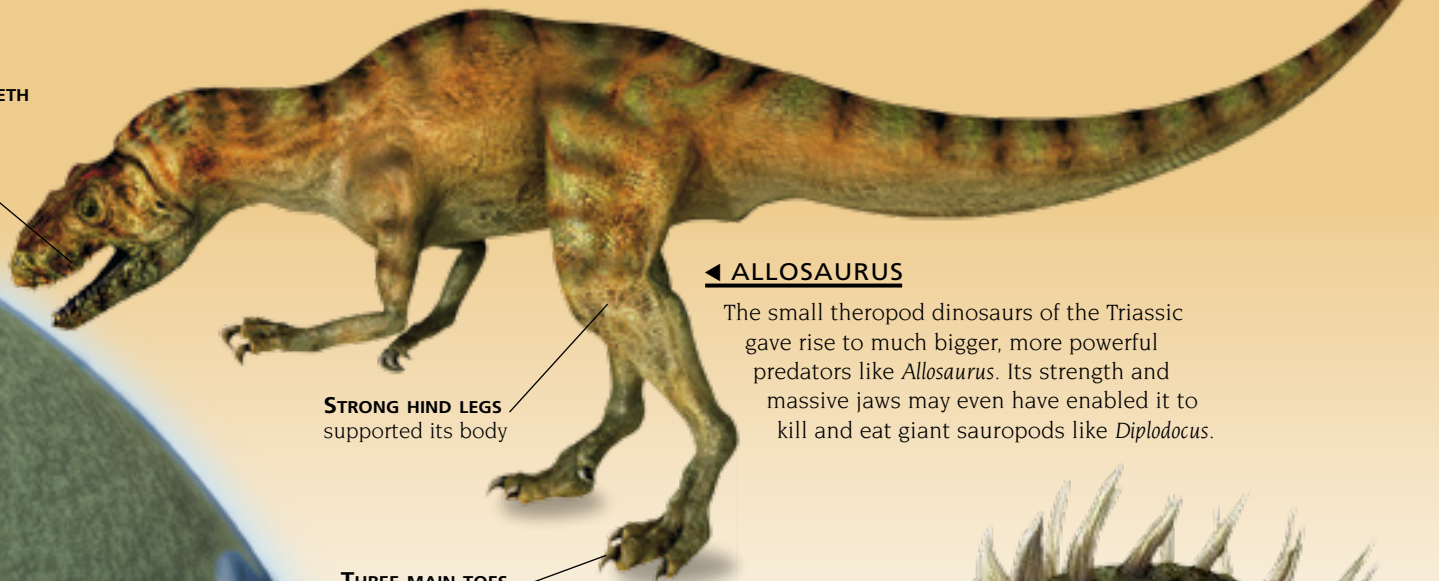
SPINY FOLIAGE of monkey puzzle may have evolved to deter hungry dinosaurs

▼ ARCHAEOPTERYX

The earliest known bird was basically a small theropod dinosaur equipped with flight feathers.



SERRATED TEETH
could slice
through skin
and flesh



STRONG HIND LEGS
supported its body

THREE MAIN TOES
had long claws

◀ **ALLOSAURUS**

The small theropod dinosaurs of the Triassic gave rise to much bigger, more powerful predators like *Allosaurus*. Its strength and massive jaws may even have enabled it to kill and eat giant sauropods like *Diplodocus*.

KENTROSAURUS ▶

The Jurassic was the era of the stegosaurs—plant-eaters with rows of plates and spikes along their backs. These provided protection from hunters like *Allosaurus*. Since they had a good blood supply, the plates and spikes may also have helped the animal lose or gain heat and regulate its body temperature.



▲ **LIOPLEURODON**

At up to 50 ft (15 m) long, *Liopleurodon* was a massive marine carnivore that could have swallowed an *Ichthyosaurus* whole. It was one of the pliosaurs—short-necked, streamlined oceanic hunters that “flew” through the water using their long flippers.

LONG FRONT TEETH
were splayed out
for seizing prey

JURASSIC PLANTS ▶

The Jurassic undergrowth resembled that of the Triassic Period, with many ferns, horsetails, mosses, and similar nonflowering plants. There was still no grass.

FOSSIL FERNS
are common in
Jurassic rocks



THE CONTINENTS
are more spread
out today



Cretaceous World

THE WARM, DAMP CLIMATES that had developed in the Jurassic continued into the Cretaceous Period, enabling the dinosaurs and other reptiles to keep evolving new forms as older ones became extinct. Some groups like the giant sauropods became less prominent, but many others flourished until the mass extinction at the end of the era. Meanwhile, the supercontinents of Laurasia and Gondwana were breaking up and very high sea levels flooded many continental areas that are now dry land.



▲ VELOCIRAPTOR

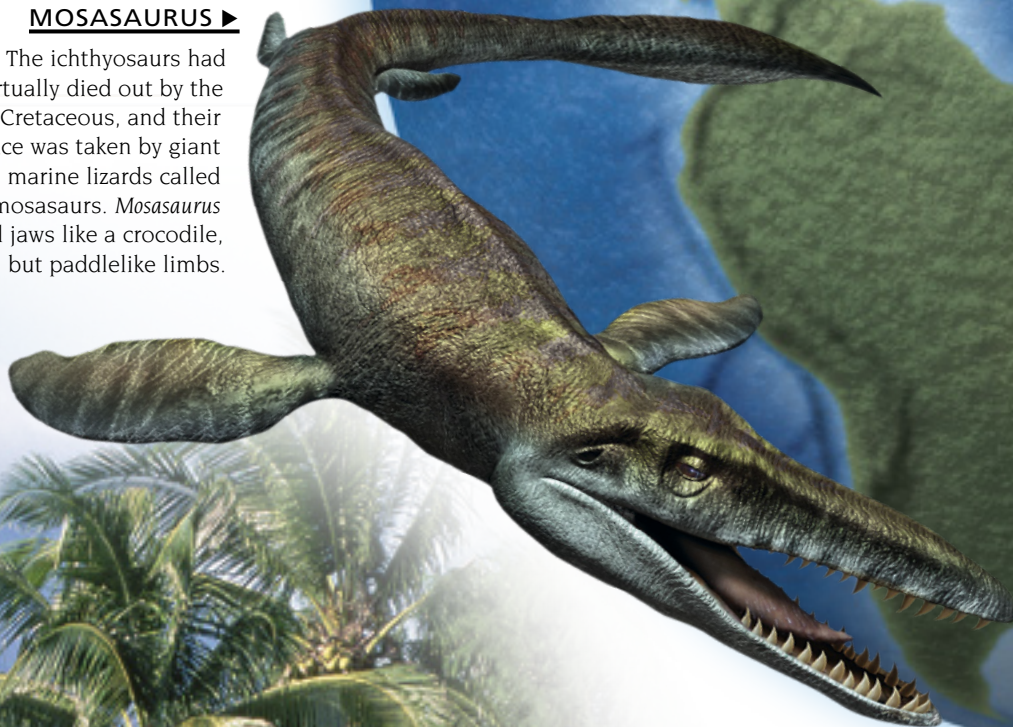
The carnivorous theropods evolved into agile, pack-hunting forms like *Velociraptor*, as well as giant tyrannosaurs. Recent research shows that *Velociraptor* may have had feathers.

CRETACEOUS GLOBE ►

The shifting plates of the Earth's crust opened great rifts in Laurasia and Gondwana, ripping them apart to form the basis of the continents we recognize today. The Atlantic began to open up as the Americas were pulled west, away from Europe and Africa, but India had still not collided with Asia.

MOSASAURUS ►

The ichthyosaurs had virtually died out by the Cretaceous, and their place was taken by giant marine lizards called mosasaurs. *Mosasaurus* had jaws like a crocodile, but paddlelike limbs.



◀ CHANGING SEASONS

Climates became more seasonal, with wet and dry seasons in some places, and winters and summers in others. Many forests were dominated by conifers and cycads, but broad-leaved trees such as oaks and beeches had appeared.

◀ QUETZALCOATLUS

The pterosaurs evolved into spectacular creatures like *Quetzalcoatlus*, which, with its 46-ft (14-m) wingspan, was the largest flying animal known to have lived. It probably soared like an albatross, barely beating its long, narrow wings. Like all the later pterosaurs, it had a very short tail.

WINGS were shaped like those of a glider

SPINOSAURUS ▶

While some hunters had developed agility and speed, others like the huge sail-backed *Spinosaurus* had evolved massive strength.

LONG ARMS may have helped catch prey

STOUT SPIKES would deter most predators

◀ ANKYLOSAURUS

Many plant-eaters developed heavy armor as protection against increasingly powerful hunters. *Ankylosaurus* was covered with bony spikes, and it could use its heavy tail club as a deadly weapon.

ATLANTIC is much broader today

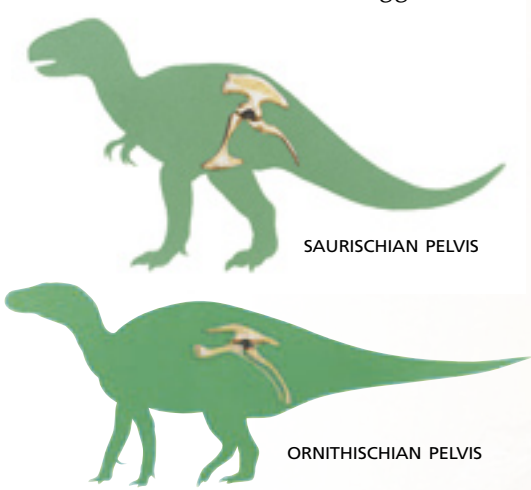
FOSSIL BROAD LEAVES are found in Cretaceous rocks

FLOWERING PLANTS ▶

The Cretaceous saw the appearance of flowering plants like this magnolia. They were so successful that they soon dominated the landscape, and the flowers encouraged the evolution of new forms of insects.

What is a Dinosaur?

THE DINOSAURS EVOLVED from reptiles called the archosaurs, which were also the ancestors of modern crocodiles. But unlike the sprawling crocodiles, dinosaurs walked on upright legs, which is more efficient. Some were probably warm-blooded, with insulating feathers. They all lived on land and laid eggs.



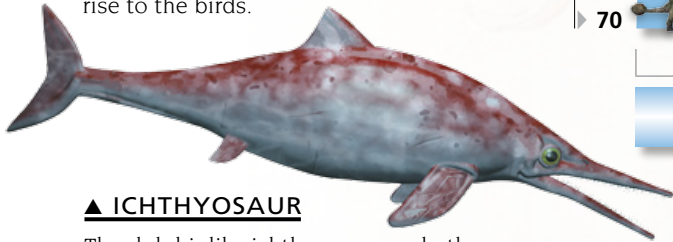
▲ **DINOSAUR HIPS**

There were two main types of dinosaur. Giant sauropods like *Diplodocus* and ferocious theropods like *Tyrannosaurus* were “lizard-hipped” saurischians, with a large bone called the pubis pointing down between the hind legs. Other dinosaurs like *Iguanodon* were “bird-hipped” ornithischians, with a smaller pubis. Confusingly, modern birds actually evolved from saurischian dinosaurs.



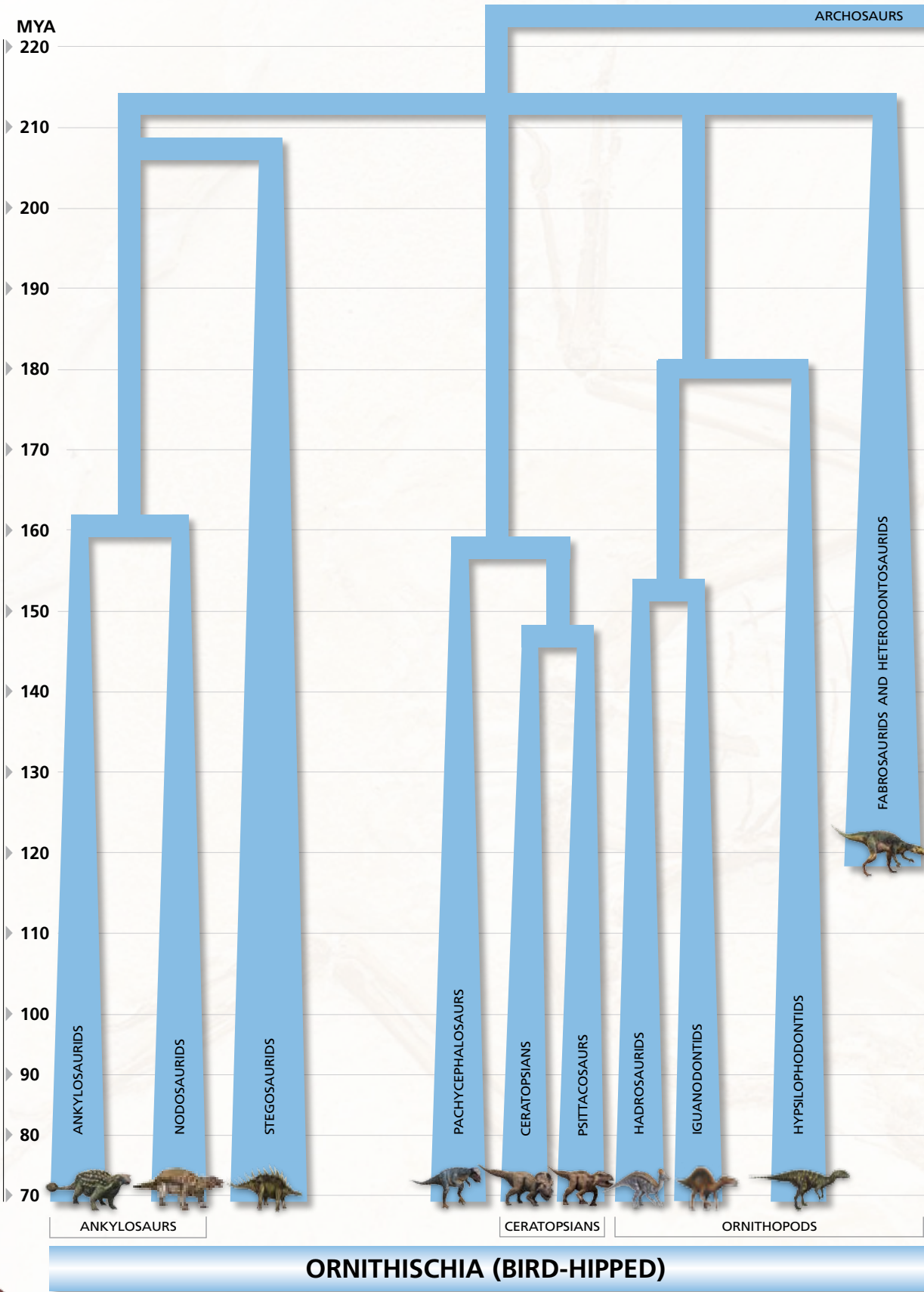
▲ **PTEROSAUR**

The pterosaurs were not dinosaurs, but they had the same archosaur ancestors. They had a lot in common with the dinosaurs, but were not related to the group that eventually gave rise to the birds.



▲ **ICHTHYOSAUR**

The dolphinlike ichthyosaurs and other marine reptiles were part of a group called the euryapsids. These evolved separately from the archosaurs, but lived at the same time.





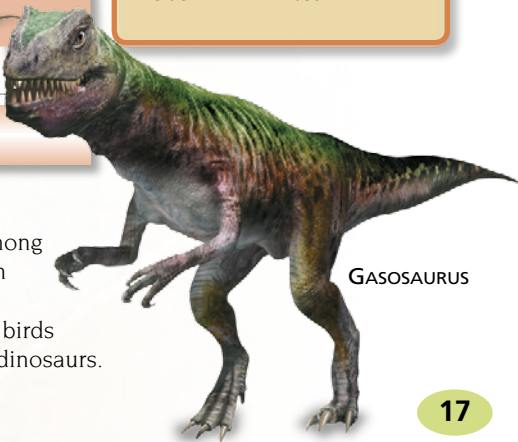
DINOSAUR NAMES

Dinosaur names are built up from parts of mainly Greek words, with some Latin. The word “dinosaur” itself comes from the Greek *deinos*, meaning “terrible,” and *sauros* meaning “lizard” or “reptile.” So it means “terrible reptile.” More of these words are listed below, with their meanings.

Acro	top
Allo	strange
Alti	high
Brachio	arm
Brachy	short
Bronto	thunder
Cera	horned
Cheirus	hand
Coelo	hollow
Compso	pretty
Corytho	helmet
Derm	skin
Di	two
Diplo	double
Docus	beam
Echino	spiny
Elaphro	light
Hetero	different
Hypsi	high
Lepto	slender
Lopho	ridge, crest
Mega	huge
Micro	small
Odon(t)	tooth
Ophthalmo	eye
Pachy	thick
Physis	body
Plateo	flat
Pod, pus, pes	foot
Poly	many
Ptero	winged
Quadri	four
Raptor	thief
Rhino	nose
Salto	jumping
Saurus	lizard, reptile
Stego	roofed
Thero	beast
Tops	head, face
Tri	three
Tyranno	tyrant
Veloci	fast

THEROPODS ►

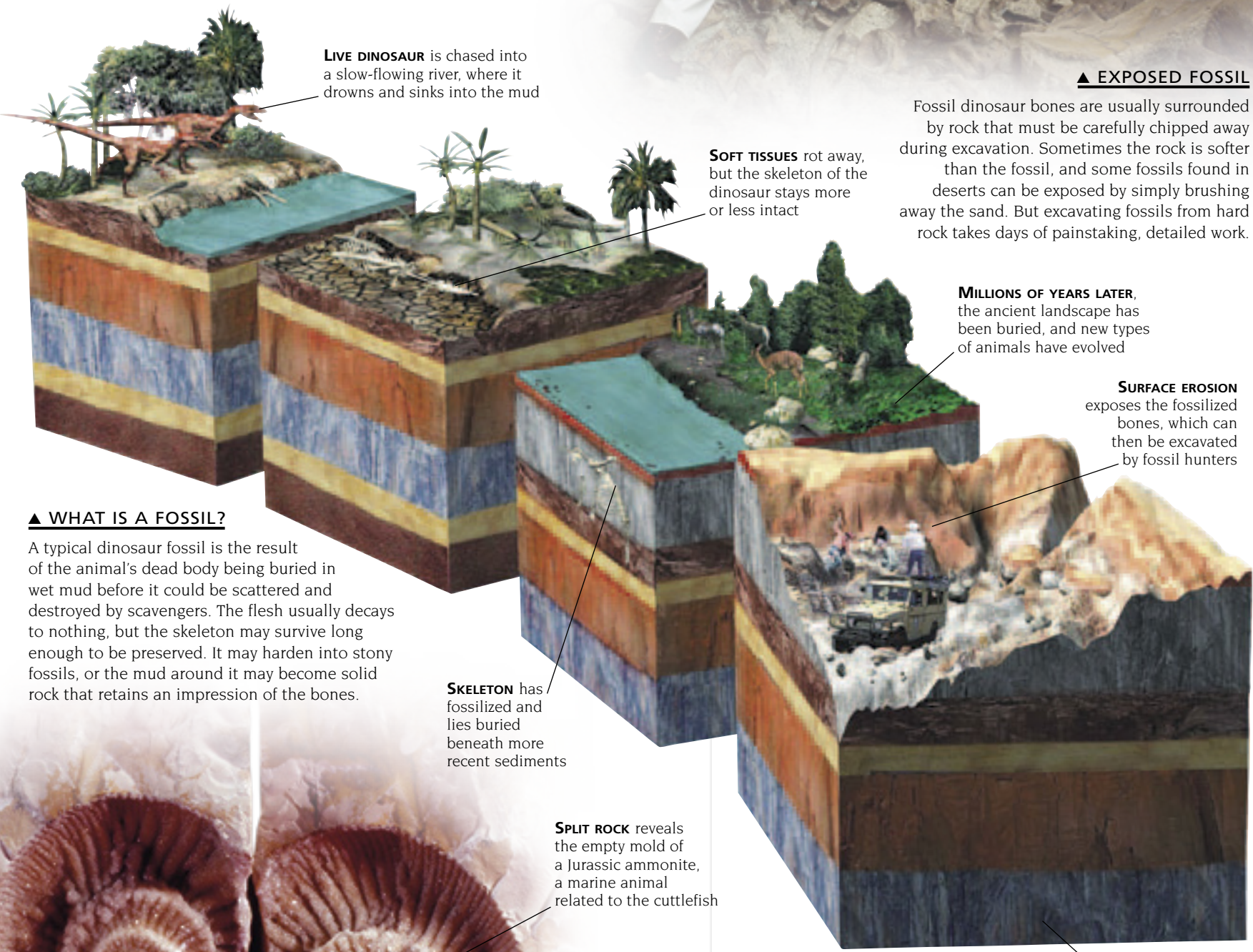
These meat-eating dinosaurs were among the most successful of the saurischian dinosaurs. Birds probably evolved from small theropods, and if so, then birds are the only living descendants of the dinosaurs.



GASOSAURUS

Fossil Record

EVERYTHING THAT WE KNOW ABOUT DINOSAURS has been worked out from their fossils. Most fossils are of tough teeth and bones, which have been buried and gradually turned to stone by minerals replacing the once-living tissue. This usually happens under water, so fossils of sea creatures are much more common than fossils of land animals like dinosaurs. Many dinosaur species have left only fragmentary fossils, such as a few teeth or the odd leg bone. It is also very rare for soft tissues like skin to be fossilized. So the “fossil record” is incomplete, and many details of dinosaur anatomy are unknown.



▲ WHAT IS A FOSSIL?

A typical dinosaur fossil is the result of the animal's dead body being buried in wet mud before it could be scattered and destroyed by scavengers. The flesh usually decays to nothing, but the skeleton may survive long enough to be preserved. It may harden into stony fossils, or the mud around it may become solid rock that retains an impression of the bones.

SKELETON has fossilized and lies buried beneath more recent sediments

SPLIT ROCK reveals the empty mold of a Jurassic ammonite, a marine animal related to the cuttlefish

◀ MOLD FOSSIL

Most animal and plant remains are completely destroyed before they can be turned into fossils. But sometimes the mud that surrounds a buried organism hardens so quickly that it forms a perfect mold of its shape. As the hard mud turns to stone the original organism disappears, leaving a cavity in the rock. This may fill with another material to form a cast.

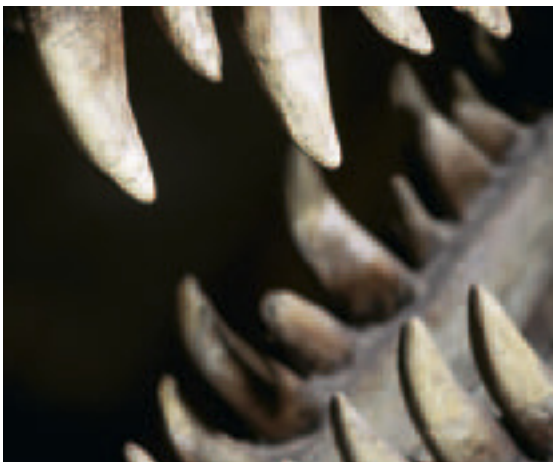
▲ EXPOSED FOSSIL

Fossil dinosaur bones are usually surrounded by rock that must be carefully chipped away during excavation. Sometimes the rock is softer than the fossil, and some fossils found in deserts can be exposed by simply brushing away the sand. But excavating fossils from hard rock takes days of painstaking, detailed work.

MILLIONS OF YEARS LATER, the ancient landscape has been buried, and new types of animals have evolved

SURFACE EROSION exposes the fossilized bones, which can then be excavated by fossil hunters

DEEPER SEDIMENTS may contain the fossil remains of much earlier life forms

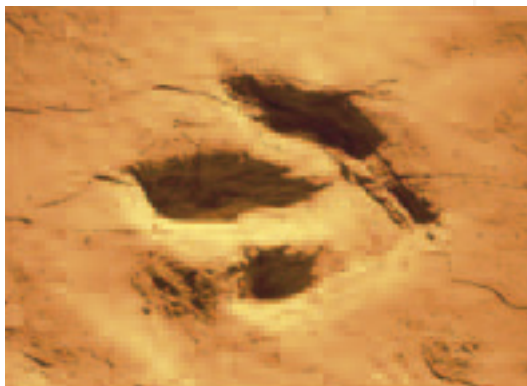


◀ TRUE FOSSIL

The big dinosaur bones that are excavated by paleontologists are usually true fossils, formed by a process of mineralization. Over millions of years, groundwater containing dissolved minerals seeps into bones that have been buried by later sediments. The minerals in the bones turn solid, somewhat like limescale forming in pipes, and this transforms the bones into stony fossils. These teeth and jaws of the giant Cretaceous hunter *Tyrannosaurus rex* were preserved in this way.

TRACE FOSSIL ▶

Some fossils do not preserve part of the animal's body, but show where it has been. These can be among the most fascinating fossils, because they give clues to how an animal lived. Dinosaur trace fossils include the remains of nests and burrows, and even fossilized droppings called coprolites. Some of the most common are footprints, like this three-toed print of a theropod.



▼ PERFECT PRESERVATION

The soft "rain" of fine sediment that settles on lake and seabeds can create finely detailed fossils of animals like fish. This freshwater perch died over 37 million years ago, but it has been preserved with its bones, skin, and delicate fin rays intact.



FOSSILIZED SKIN
and fin membranes reveal the true shape of the fish

FOSSIL PLANT ▶

Plants may also be fossilized, particularly if they are buried in airless swamps where the waterlogged conditions stop them from decaying. This fossil fern dates from the Carboniferous Period, some 300 million years ago. Many similar Carboniferous plants were buried, compressed, and turned into the "fossil fuel" we call coal.



FLIES IN AMBER ▶

Sometimes small animals are found trapped in amber, which is tree resin that has fossilized with age. These insects became stuck in the gluey resin millions of years ago, and the resin then covered them and stopped them from decaying. Every detail of their fragile bodies has been preserved.



SOME SOFT TISSUES may be preserved inside the amber, but substances like DNA are unlikely to survive

Flying Reptiles

THE BIGGEST FLYING ANIMALS that have ever existed patrolled the skies during the age of the dinosaurs. They were the pterosaurs—lightweight flying reptiles that were related to the dinosaurs. The smallest were the size of sparrows, but the largest were the size of light planes. They had hollow bones like birds, and long, typically toothed beaks. Their wings were membranes of elastic skin, rather like those of a bat, but unlike a bat's wings each was supported by a single, elongated fourth finger bone, and hundreds of tough, reinforcing fibers.



▲ PTERODAUSTRO

The pterosaurs that lived in the Cretaceous Period had short tails and long wrist bones. The jaws of *Pterodaustro* were fringed with bristlelike teeth, which it probably used to strain plankton from seawater.

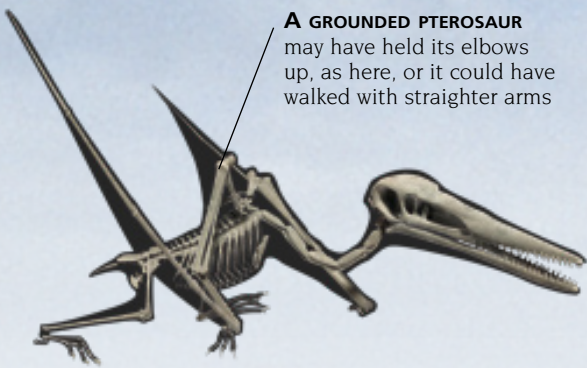
FOUR LONG BONES of the fourth finger supported the stretchy skin of the pterosaur's outer wing

▼ PTERANODON

One of the biggest pterosaurs, *Pteranodon ingens* had an elongated crest and a long, toothless beak that made its head longer than its body. It had a beak pouch like that of a pelican, and probably fed on fish.



UNUSUALLY LONG TOES of this Late Cretaceous pterosaur were likely to have been webbed



A GROUNDED PTEROSAUR may have held its elbows up, as here, or it could have walked with straighter arms

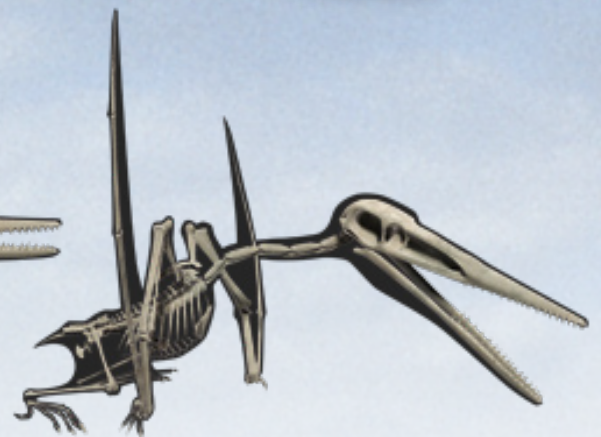
▲ FEET AND HANDS

Although specialized for flight, pterosaurs had quite strong back legs. They also had well-developed "hands" at the angle of each wing.



▲ WALKING ON WINGS

A pterosaur could have used its wings as front legs by folding their outer sections upward. It could then have walked on all fours.

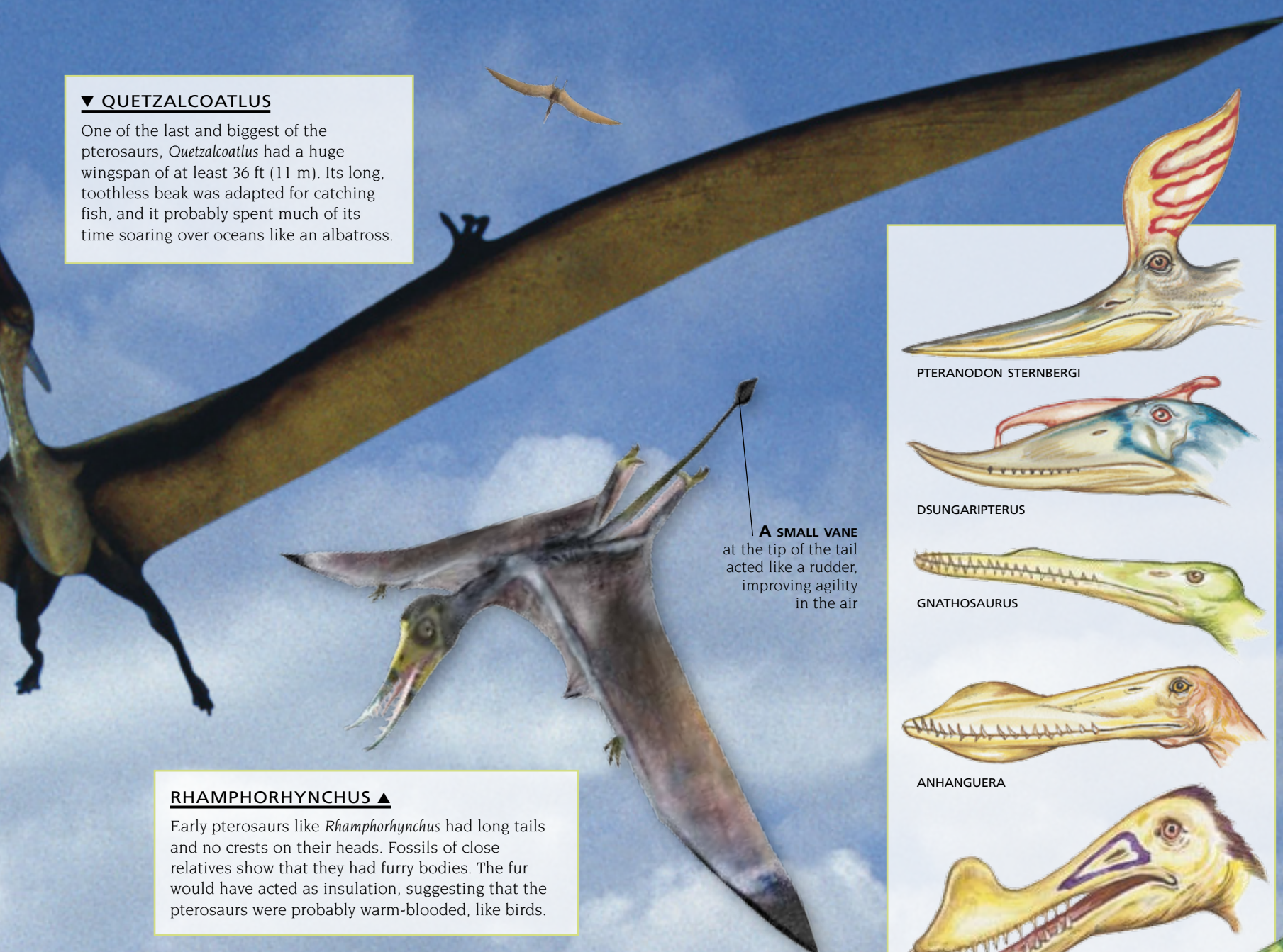


▲ AGILE AND LIGHTWEIGHT

Being lightly built, a pterosaur could have been very agile on the ground, and small pterosaurs would have been able to take off easily.

▼ QUETZALCOATLUS

One of the last and biggest of the pterosaurs, *Quetzalcoatlus* had a huge wingspan of at least 36 ft (11 m). Its long, toothless beak was adapted for catching fish, and it probably spent much of its time soaring over oceans like an albatross.



A SMALL VANE
at the tip of the tail
acted like a rudder,
improving agility
in the air

▲ RHAMPHORHYNCHUS ▲

Early pterosaurs like *Rhamphorhynchus* had long tails and no crests on their heads. Fossils of close relatives show that they had furry bodies. The fur would have acted as insulation, suggesting that the pterosaurs were probably warm-blooded, like birds.



▲ PTEROSAUR EGG

A fossil pterosaur egg recently discovered in China contained a fully developed, unhatched baby. The shape of the egg suggests that it had a soft shell, like that of a modern reptile.



▲ PTEROSAUR FOSSIL

Some pterosaurs have been preserved in fine-grained rocks that show every detail of their fragile skeletons. This fossil *Pterodactylus* was found in Late Jurassic limestone.



PTERANODON STERNBERGI



DSUNGARIPTERUS



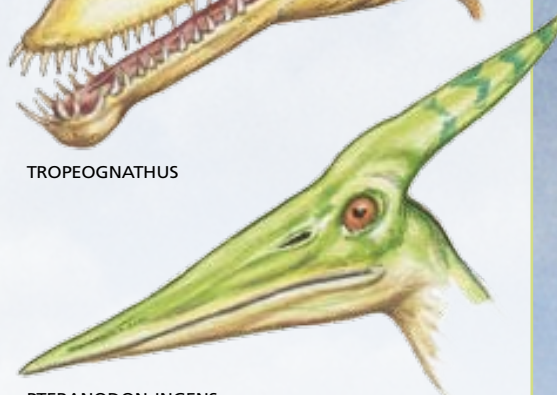
GNATHOSAURUS



ANHANGUERA



TROPEOGNATHUS



PTERANODON INGENS



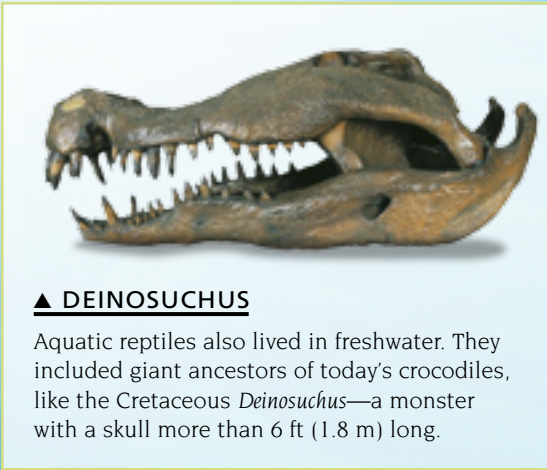
GERMANODACTYLUS

▲ COLORFUL CRESTS

Many of the advanced pterosaurs of the Cretaceous had bony crests on their skulls or jaws. Some fossils show traces of soft extensions to these crests, which may have been brightly colored. Male pterosaurs seem to have had bigger crests than females, and they were probably used to enhance courtship displays.

Reptiles in the Sea

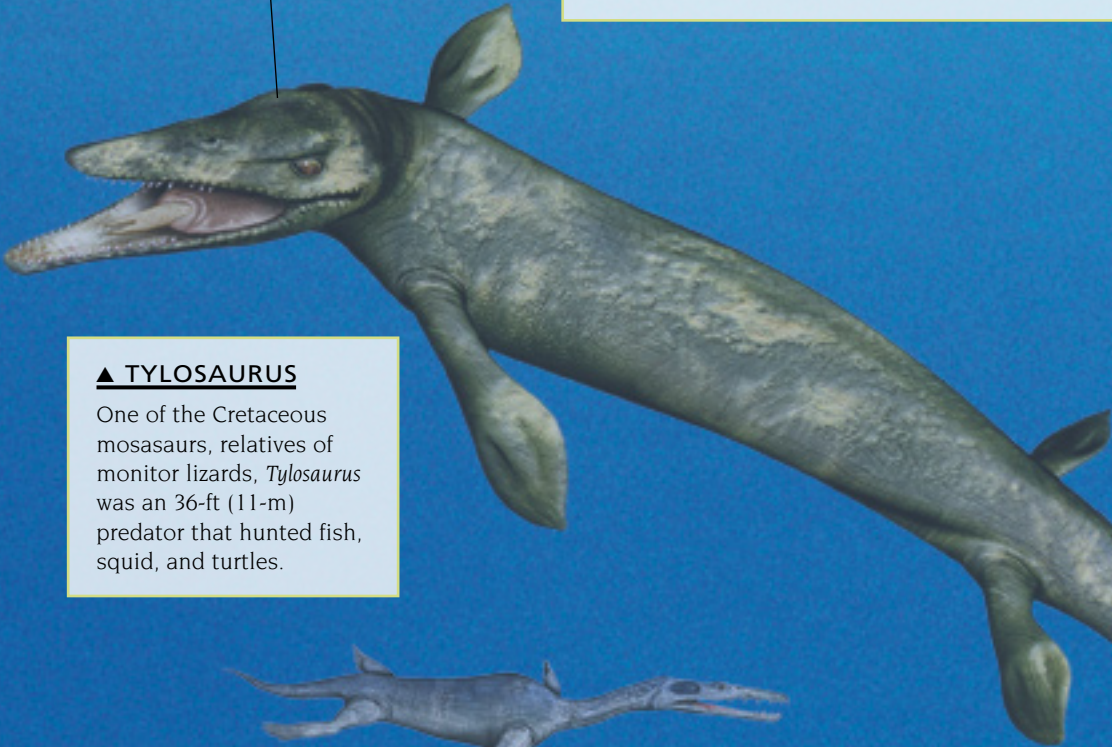
THE MARINE REPTILES OF THE MESOZOIC ERA were only distantly related to the dinosaurs, but they lived at the same time and probably preyed on them if they got the chance. Many were giants with formidable jaws, and some were as highly adapted to life in the water as modern whales and dolphins. Since they lived in the sea, where fossilization is much more likely, many of their fossils are superbly preserved, complete with the remains of the animals that they had eaten just before they died. One fossil ichthyosaur even captures the moment of birth, showing that its young were born fully formed and tail first, like those of porpoises.



LONG, NARROW SNOUT
was equipped with many large teeth for seizing tough-shelled ammonites

▲ TEMNODONTOSAURUS
The ichthyosaurs were reptiles that preyed on fish, squid, and ammonites. They appeared in the Triassic Period, and were abundant in Jurassic oceans. At 30 ft (9 m) long, *Temnodontosaurus* was one of the biggest.

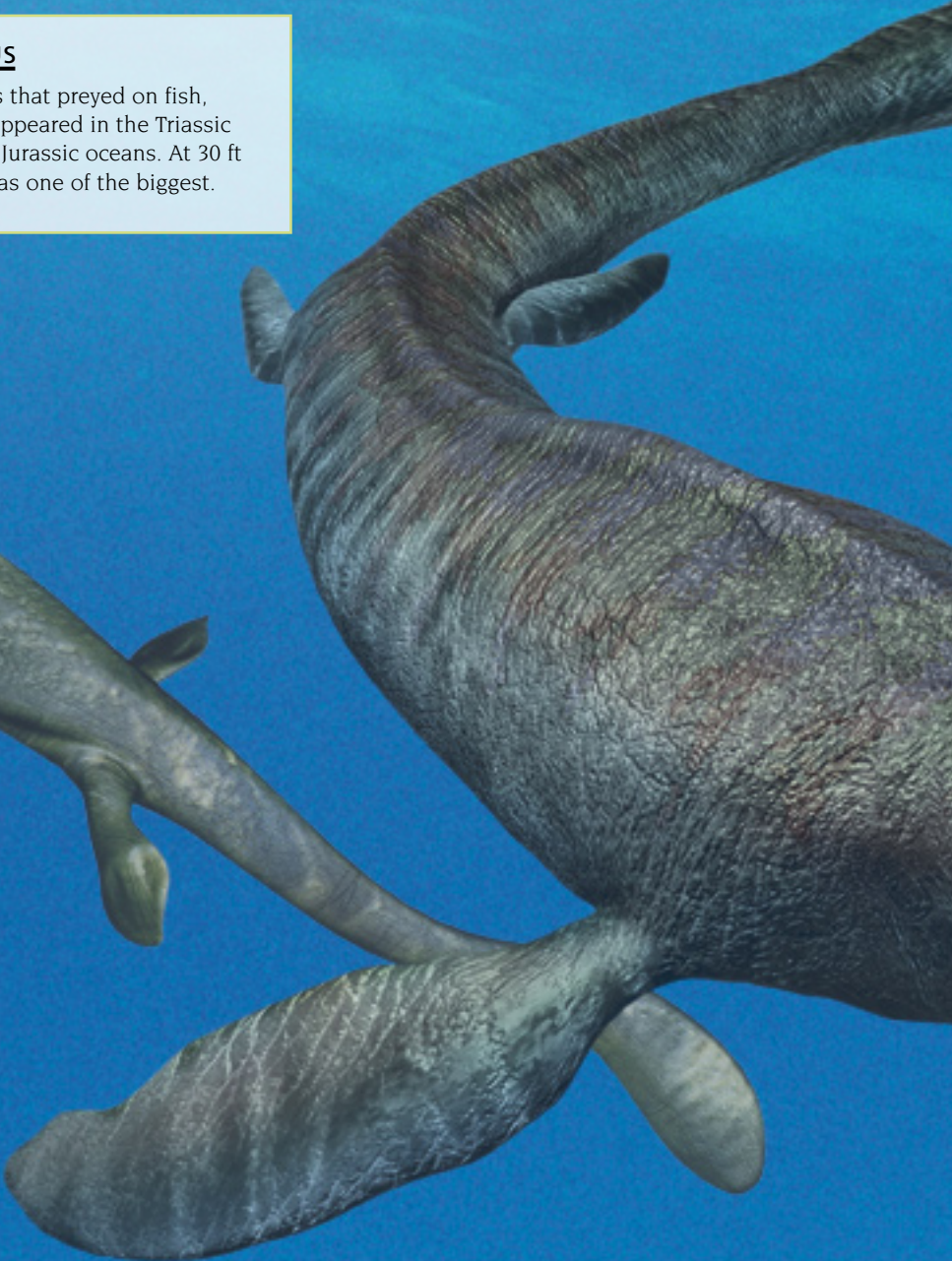
MOBILE SKULL BONES
allowed this predatory marine lizard to swallow large prey whole



▲ TYLOSAURUS
One of the Cretaceous mosasaurs, relatives of monitor lizards, *Tylosaurus* was an 36-ft (11-m) predator that hunted fish, squid, and turtles.



▲ NOTHOSAURUS
This slender animal was a typical nothosaur—reptiles that lived in shallow Triassic seas and fed mainly on fish. Unlike many marine reptiles they probably bred on beaches, like seals.



▼ ARCHELON ▲

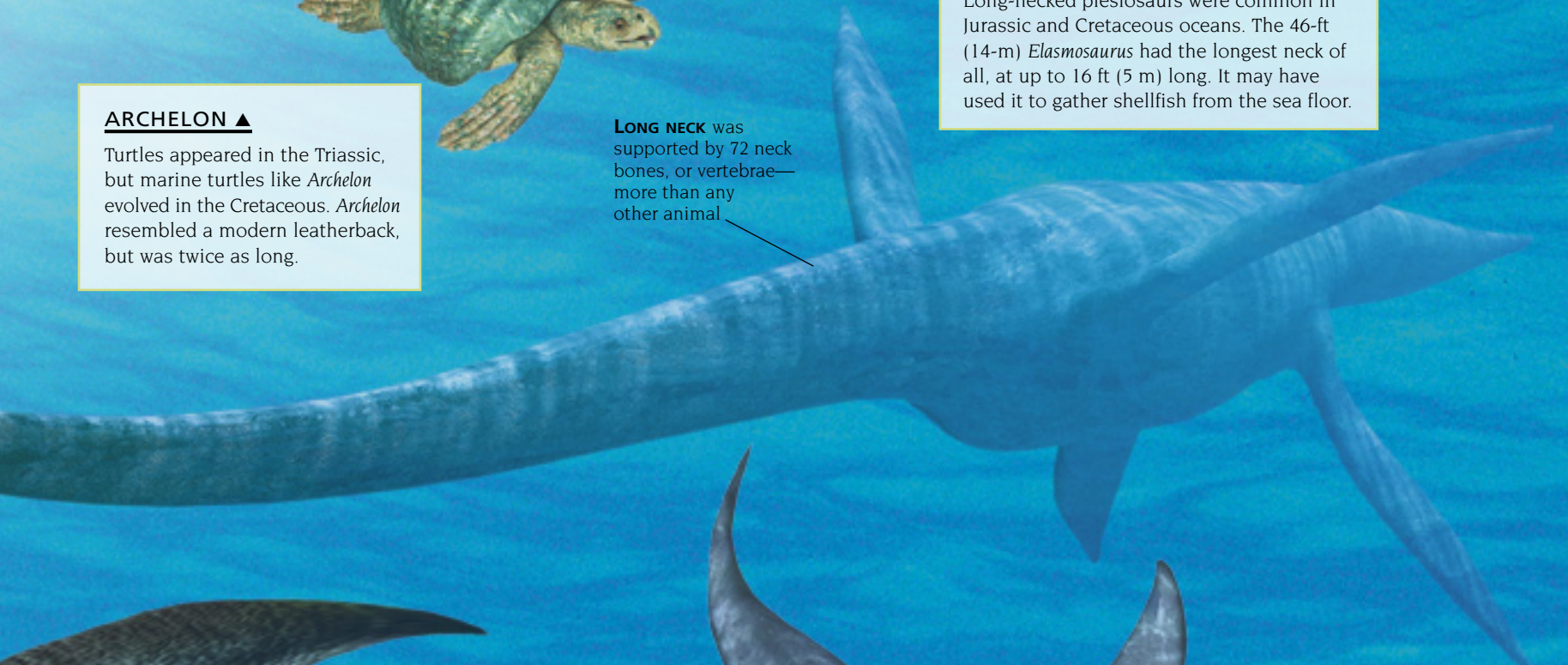
Turtles appeared in the Triassic, but marine turtles like *Archelon* evolved in the Cretaceous. *Archelon* resembled a modern leatherback, but was twice as long.



LONG NECK was supported by 72 neck bones, or vertebrae—more than any other animal

▼ ELASMOSAURUS

Long-necked plesiosaurs were common in Jurassic and Cretaceous oceans. The 46-ft (14-m) *Elasmosaurus* had the longest neck of all, at up to 16 ft (5 m) long. It may have used it to gather shellfish from the sea floor.

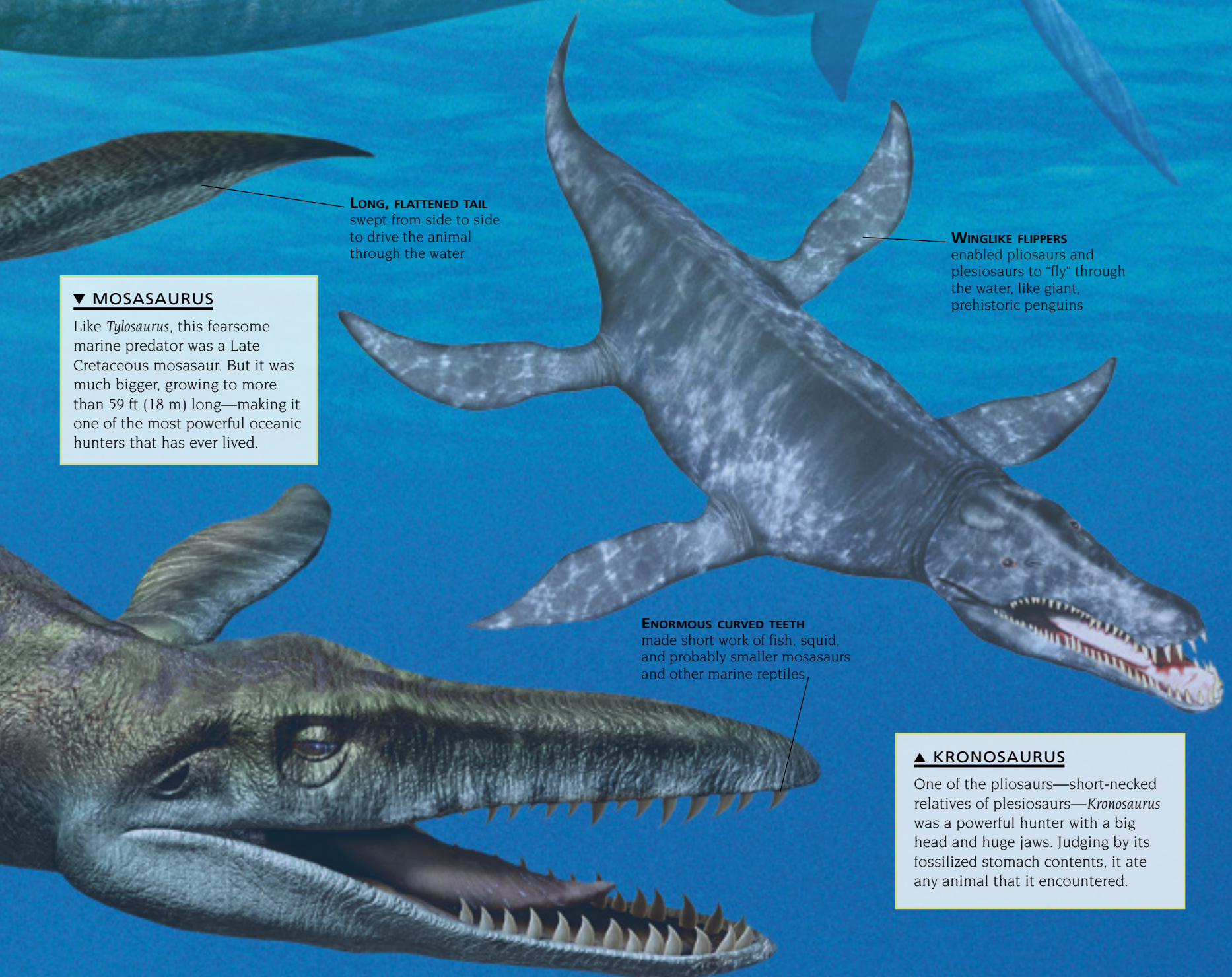


LONG, FLATTENED TAIL swept from side to side to drive the animal through the water

WINGLIKE FLIPPERS enabled plesiosaurs and plesiosaurs to “fly” through the water, like giant, prehistoric penguins

▼ MOSASAURUS

Like *Tylosaurus*, this fearsome marine predator was a Late Cretaceous mosasaur. But it was much bigger, growing to more than 59 ft (18 m) long—making it one of the most powerful oceanic hunters that has ever lived.



ENORMOUS CURVED TEETH made short work of fish, squid, and probably smaller mosasaurs and other marine reptiles

▲ KRONOSAURUS

One of the plesiosaurs—short-necked relatives of plesiosaurs—*Kronosaurus* was a powerful hunter with a big head and huge jaws. Judging by its fossilized stomach contents, it ate any animal that it encountered.

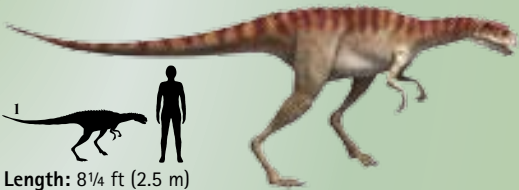
North America



DINOSAUR FOSSILS have been discovered at nearly 300 different locations in North America. They are found in the western interior, the southwest, and the eastern seaboard, in rocks that formed during the age of dinosaurs, from the Late Triassic to the end of the Cretaceous. Throughout these 170 million years, an unknown number of dinosaur species lived on the continent's slowly changing landscape and, so far, paleontologists have identified about 70 different kinds. They belong to all the major dinosaur groups, and several species, such as *Tyrannosaurus*, *Diplodocus*, and *Stegosaurus*, are some of the best known dinosaurs in the world.

KEY	 TRIASSIC PERIOD	 SITE  FORMATION
	 JURASSIC PERIOD	
	 CRETACEOUS PERIOD	

CHINDESAURUS



Length: 8¼ ft (2.5 m)
Pronunciation: chin-de-sore-us
Meaning: "Chinde lizard"

COELOPHYSIS



Length: 8¼ ft (2.5 m)
Pronunciation: seel-oh-fie-sis
Meaning: "hollow form"

GOJIRASAURUS



Length: 21 ft (6.5 m)
Pronunciation: go-jeer-a-sore-us
Meaning: "godzilla lizard"

PEACE RIVER

More than 1,700 dinosaur tracks have been found here, made 125 million years ago.



ALASKA (USA)

PEACE RIVER
British Columbia

Footprints

CANADA

DINOSAUR PROVINCIAL PARK
Alberta

HELL CREEK
Montana

DINOSAUR NATIONAL MONUMENT
Utah/Colorado

CEDAR MOUNTAIN FORMATION
Utah

PETRIFIED FOREST
Arizona

GHOST RANCH
New Mexico

MORRISON FORMATION

Formed during the Jurassic Period, this vast area of sandstone, mudstone, and limestone is famous for its many dinosaurs.

THE MAP

Some of North America's major dinosaur locations are shown on this map, together with the dinosaurs found there.

UNITED STATES OF AMERICA

MOUNT TOM
Massachusetts
HADDONFIELD
NEW JERSEY

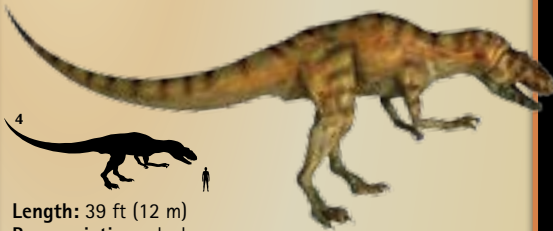
Footprints

DINOSAUR TRACKS

In the riverbed of the Paluxy River, Texas, are tracks left by dinosaurs as they walked along the shore of an ancient sea, 113 million years ago.

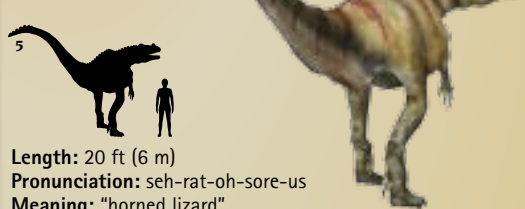


ALLOSOSAURUS



Length: 39 ft (12 m)
Pronunciation: al-oh-sore-us
Meaning: "different lizard"

CERATOSAURUS



Length: 20 ft (6 m)
Pronunciation: seh-rat-oh-sore-us
Meaning: "horned lizard"

DIPLODOCUS



Length: 89 ft (27 m)
Pronunciation: di-ploh-do-kus
Meaning: "double beam"

STEGOSAURUS



Length: 30 ft (9 m)
Pronunciation: steg-oh-sore-us
Meaning: "roof lizard"

ALBERTOSAURUS



Length: 16 ft (5 m)
Pronunciation: al-bert-oh-sore-us
Meaning: "Alberta lizard"

CENTROSAURUS



Length: 20 ft (6 m)
Pronunciation: sen-troh-sore-rus
Meaning: "pointed lizard"

CORYTHOSAURUS



Length: 33 ft (10 m)
Pronunciation: koh-rith-oh-sore-us
Meaning: "helmet lizard"

DEINONYCHUS



Length: 9 ft (2.7 m)
Pronunciation: die-non-i-kus
Meaning: "terrible claw"

EDMONTONIA



Length: 20 ft (6 m)
Pronunciation: ed-mon-tone-ee-ah
Meaning: "of Edmonton" (after a Canadian city)

EDMONTOSAURUS



Length: 43 ft (13 m)
Pronunciation: ed-mon-toh-sore-us
Meaning: "Edmonton lizard"

EUOPLOCEPHALUS



Length: 20 ft (6 m)
Pronunciation: you-op-loh-sef-ah-lus
Meaning: "well armored head"

GASTONIA



Length: 16 ft (5 m)
Pronunciation: gas-tone-ee-a
Meaning: "of Gaston" (after Robert Gaston, its finder)

PACHYCEPHALOSAURUS



Length: 33 ft (10 m)
Pronunciation: pack-ee-sef-a-lo-sore-us
Meaning: "thick-headed lizard"

TENONTOSAURUS



Length: 23 ft (7 m)
Pronunciation: ten-on-toe-sore-us
Meaning: "sinew lizard"

TRICERATOPS



Length: 30 ft (9 m)
Pronunciation: try-serra-tops
Meaning: "three-horned face"

TROODON



Length: 6½ ft (2 m)
Pronunciation: troo-oh-don
Meaning: "wounding tooth"

TYRANNOSAURUS



Length: 39 ft (12 m)
Pronunciation: tie-ran-oh-sore-us
Meaning: "tyrant lizard"

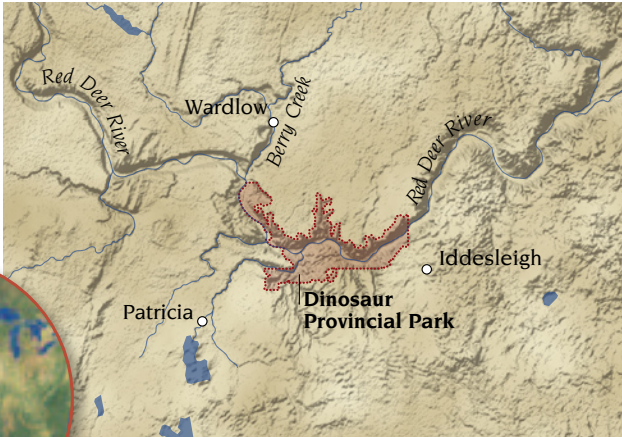
UTAHRAPTOR



Length: 16 ft (5 m)
Pronunciation: yoo-tah-rap-tor
Meaning: "Utah plunderer"

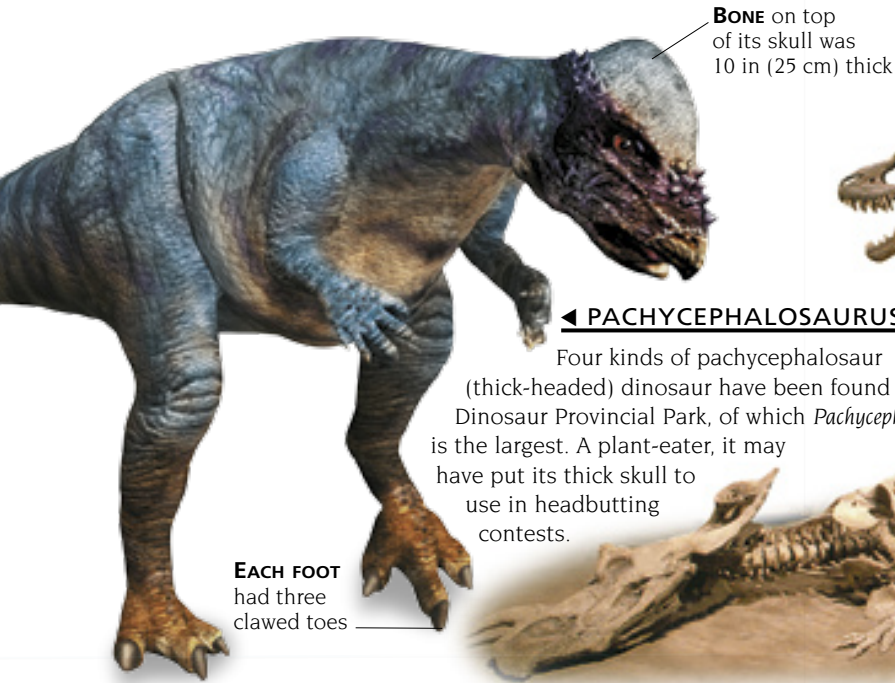
Provincial Park

ONE OF THE WORLD'S great dinosaur locations is Dinosaur Provincial Park, along the Red Deer River in southern Alberta, Canada. In 1910, after a farmer found dinosaur bones on his land, paleontologists began to study the area. Almost 40 different species of Late Cretaceous dinosaur have been found here, including *Corythosaurus*, *Centrosaurus*, *Pachycephalosaurus*, and *Euoplocephalus*. They lived about 75 million years ago, when the area was marshy land at the mouth of a river and the climate was warm. Today, Dinosaur Provincial Park is a vast area of rocky, arid land.



▲ SITE LOCATION

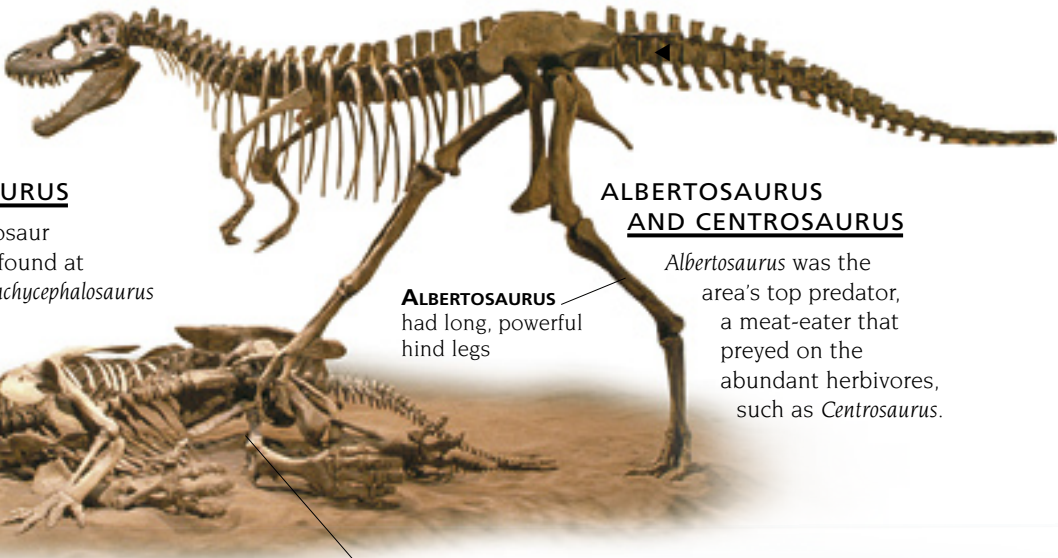
Dinosaur Provincial Park was established in 1955, and in 1979 it became a World Heritage Site. The park covers 28 sq miles (73 sq km).



◀ PACHYCEPHALOSAURUS

Four kinds of pachycephalosaur (thick-headed) dinosaur have been found at Dinosaur Provincial Park, of which *Pachycephalosaurus* is the largest. A plant-eater, it may have put its thick skull to use in headbutting contests.

EACH FOOT had three clawed toes



ALBERTOSAURUS AND CENTROSAURUS

ALBERTOSAURUS had long, powerful hind legs

Albertosaurus was the area's top predator, a meat-eater that preyed on the abundant herbivores, such as *Centrosaurus*.

CENTROSAURUS was a big animal, with enough meat on it for many meals

▼ EVER-CHANGING LANDSCAPE

The area was once a subtropical forest of giant redwood trees and palms, swamp grass, and reeds. Rivers flowed through here, shedding sediments that set into layers of rock. Time passed until, 12,000 years ago, meltwaters from retreating glaciers cut through the rock, leaving the terrain seen today.

ROCK LAYERS are 400 ft (120 m) deep, formed over 2 million years

DID YOU KNOW?

A *Centrosaurus* bone bed was unearthed in Dinosaur Provincial Park—it held the remains of more than 50 individuals. Scientists believe that they may have been washed away together by a storm.

◀ EUOPLOCEPHALUS

This strange-looking dinosaur is the only species of ankylosaur (armoured dinosaur) found at Dinosaur Provincial Park.

A two-ton plant-eater, its head and back were covered in bands of bony nodules, and its tail ended in a heavy bone club. Even its eyelids had a layer of bone over them. These features were for self-protection, shielding *Euoplocephalus* from meat-eating predators.





CORYTHOSAURUS SKELETON

Many well-preserved adult *Corythosaurus* skeletons have been found at Dinosaur Provincial Park, including this example, which only lacks part of its tail and hands. The dinosaur's body shape can be reconstructed with great accuracy because it is so well-preserved.



CORYTHOSAURUS

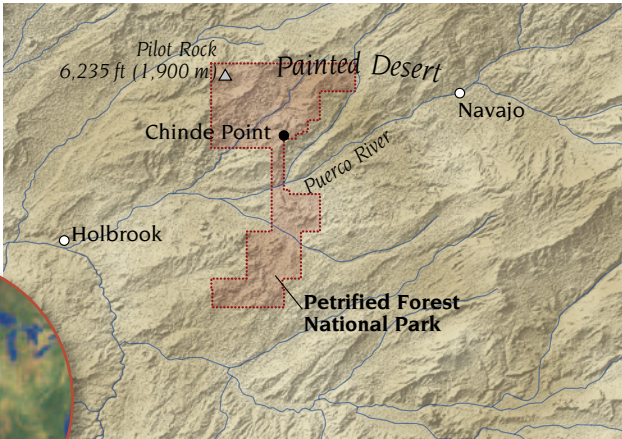
The most common dinosaur in the area was *Corythosaurus*, a hadrosaur (duck-bill). A swamp-dweller and herbivore, it lived in herds. Its crest had many nasal passages, which it may have used to make sounds.

LATE CRETACEOUS PLANTS

In the Late Cretaceous a great variety of plants grew in the swamps and surrounding landscape, providing a supply of food for the many herbivores that lived here. More than 170 different species of plant have been identified in the area.

Petrified Forest

IN NORTHEASTERN ARIZONA there is a remarkable site from the Late Triassic. About 220 million years ago, a great forest of conifer trees grew somewhere in this area. In times of flood many were uprooted, carried along by the water, and piled up in heaps on the land, where they were slowly fossilized. Today, these ancient tree trunks lie scattered across the landscape, in an area known as the Petrified Forest National Park. There are also fossils of the world's first dinosaurs, such as *Chindesaurus*, together with amphibians and large-tusked plant-eaters called dicynodonts.



▲ SITE LOCATION

Petrified Forest National Park was established in 1962. As early as 1899, the United States Geological Survey had sought to protect the area. It covers 342 sq miles (885 sq km).

◀ FOREST OF GIANTS

The fossilized trees of the Petrified Forest National Park mainly belong to the Araucariaceae family. They were conifers, many of which were similar to today's monkey puzzle trees. From their fossilized trunks it's clear that when fully grown the trees reached heights of around 165 ft (50 m), with trunks more than 2 ft (60 cm) across. Down on the ground, where light levels were low, grew ferns and horsetails.



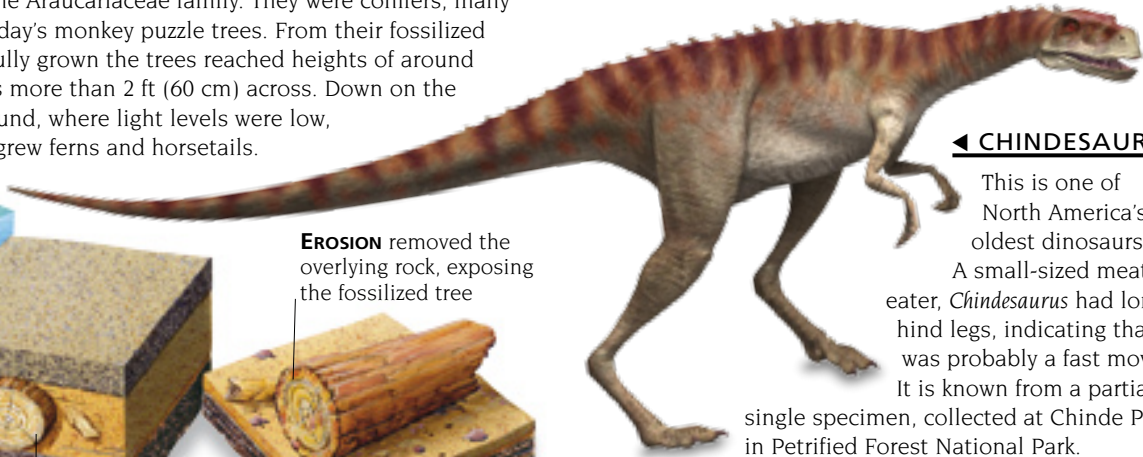
▼ TODAY'S LANDSCAPE

The fossilized trees lie where ancient floodwaters dropped them, more than 200 million years ago. Since then, wind, water, and ice have weathered away the rock that entombed them, leaving them visible on the land surface. As the minerals that transformed their bark and wood into stone are brightly colored, these petrified logs are sometimes known as "rainbow wood."

RED of the fossilized trees is from the mineral hematite, a form of iron oxide.

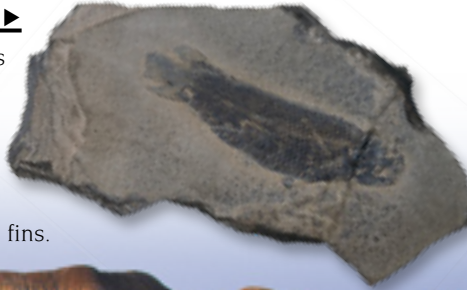
◀ CHINDESAURUS

This is one of North America's oldest dinosaurs. A small-sized meat-eater, *Chindesaurus* had long hind legs, indicating that it was probably a fast mover. It is known from a partial single specimen, collected at Chinde Point in Petrified Forest National Park.



LUNGFISH FOSSIL ▶

Out of the area's sandstone rocks come the fossils of lungfish, revealing that long ago the landscape had rivers and lakes where these animals lived. Ancient lungfish, like those of today, were fish that could breathe air, with limbs more like flippers than fins.

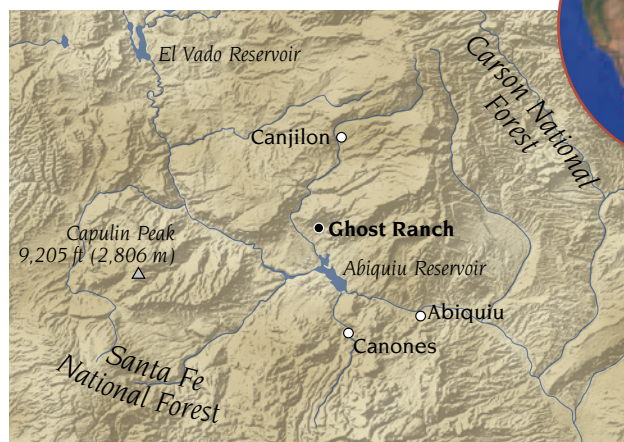




Ghost Ranch

▲ AT HOME ON THE FLOODPLAIN

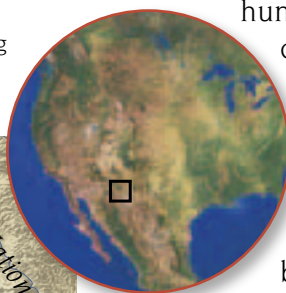
The discovery of hundreds of *Coelophysis* skeletons at Ghost Ranch is strong evidence that they lived in herds. The clue is in the fact that the skeletons appear to have been brought together suddenly at the same time, not slowly over a long period. How could this have happened? One explanation is that a herd drowned in a flash flood; another is that they died while trying to cross a river. Either way, their bodies were quickly buried under sediment.



▲ SITE LOCATION

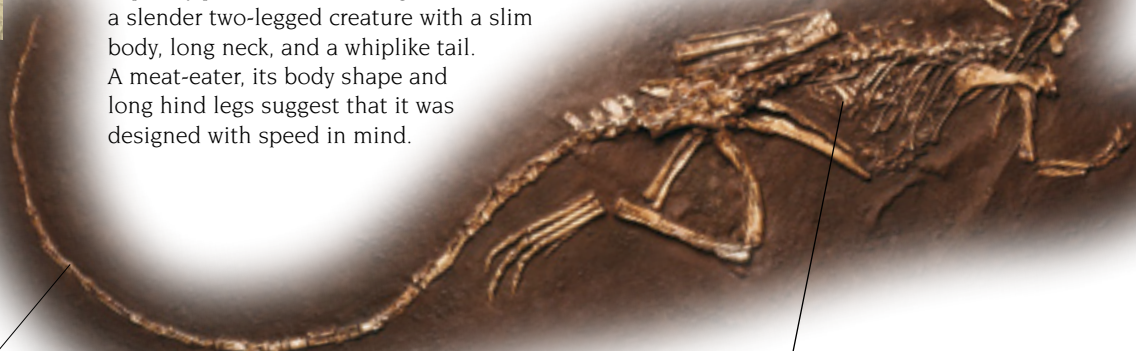
The Ghost Ranch dinosaur quarry is in the Chama River Valley, near the northern New Mexico town of Abiqui. The fossils occur within a thin bed of red sandstone.

IN NORTHERN NEW MEXICO there is a famous fossil quarry from where hundreds of skeletons of *Coelophysis* have been excavated. This small dinosaur lived in the Late Triassic, and at around 220 million years old it is one of the world's oldest dinosaurs. The bone bed where so many were found is named Ghost Ranch, after a nearby farm. It lies east of Arizona's Petrified Forest National Park, and both sites belong to the Chinle Formation of rocks. These ancient fossil-bearing rocks began as soft layers of sediment, deposited by rivers on their floodplains. Long ago, a herd of *Coelophysis* sank into the soft Triassic mud, where they lay buried until excavations uncovered them in the late 1940s.



▼ COELOPHYSIS SKELETON

Many of the Ghost Ranch *Coelophysis* skeletons are superbly preserved, revealing the animal to be a slender two-legged creature with a slim body, long neck, and a whiplike tail. A meat-eater, its body shape and long hind legs suggest that it was designed with speed in mind.



A BABY COELOPHYSIS SKELETON within the stomach area of an adult suggests *Coelophysis* was a cannibal

LONG TAIL probably counterbalanced the weight of its body when it moved around

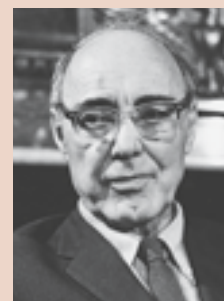
LONG HEAD with many small, sharp teeth packed into its jaws

SHORT ARMS with hands and clawed fingers built for grasping and scratching

◀ GOJIRASAUROS

This dinosaur is one of the biggest Late Triassic carnivores. It seems to have resembled *Coelophysis*, though twice as big, weighing as much as 440 lb (200 kg). Known from a single, incomplete skeleton, *Gojirasaurus* is named after Gojira, which is the Japanese name for the movie monster Godzilla.

Edwin Colbert



American paleontologist Dr. Edwin Colbert (1905–2001) discovered more than 500 skeletons of *Coelophysis* at the Ghost Ranch quarry in 1947. His work on Antarctica also helped to confirm the theory of plate tectonics, or "continental drift."

Dinosaur Monument

DINOSAUR NATIONAL MONUMENT is in a remote part of Colorado and Utah, in the western United States. It is a protected area of more than 200,000 acres, where hundreds of Late Jurassic dinosaurs have been found, including the meat-eaters *Allosaurus* and *Ceratosaurus*, the plant-eaters *Diplodocus* and *Stegosaurus*, together with about 15 other species. They lived 150 million years ago, on low-lying ground over which a great river periodically flooded. As it spilled across its floodplain, it washed the carcasses of dead dinosaurs onto a sandbank, where they were slowly fossilized.

Cope and Marsh

In the 1870s, two American fossil hunters, Edward Drinker Cope (1840–97) and Othniel Charles Marsh (1831–99), began searching for dinosaur fossils within the rocks of the Morrison Formation. They competed to see who could find the best specimens, and who could name the most new species. Their bitter rivalry lasted for many years, and is now known as the “Bone Wars.”



EDWARD DRINKER COPE OTHNIEL CHARLES MARSH

TODAY’S LANDSCAPE ►

Visitors to the Dinosaur National Monument see an area of high sandstone cliffs, and the valleys of the Green and Yampa Rivers. The cliffs are part of the Morrison Formation—an extensive deposit created in the Late Jurassic from sediments spread by rivers across their floodplains.



► STEGOSAURUS SKELETON

More than 300 tons of dinosaur fossils were recovered from the bone bed, including the skeleton of *Stegosaurus*, a plant-eating dinosaur with bony plates on its back.

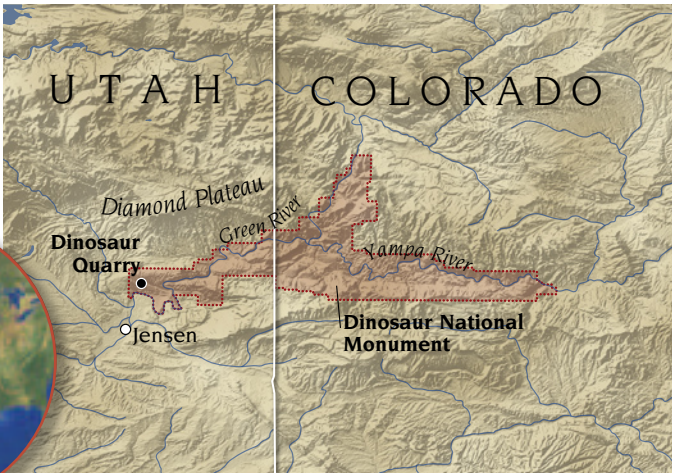


▲ DIPLODOCUS SKULL

Several almost complete *Diplodocus* skeletons were excavated. This giant sauropod (a plant-eating dinosaur), whose small head was just 1½ ft (0.5 m) long, stripped leaves from trees with its peglike teeth.

▲ SITE LOCATION

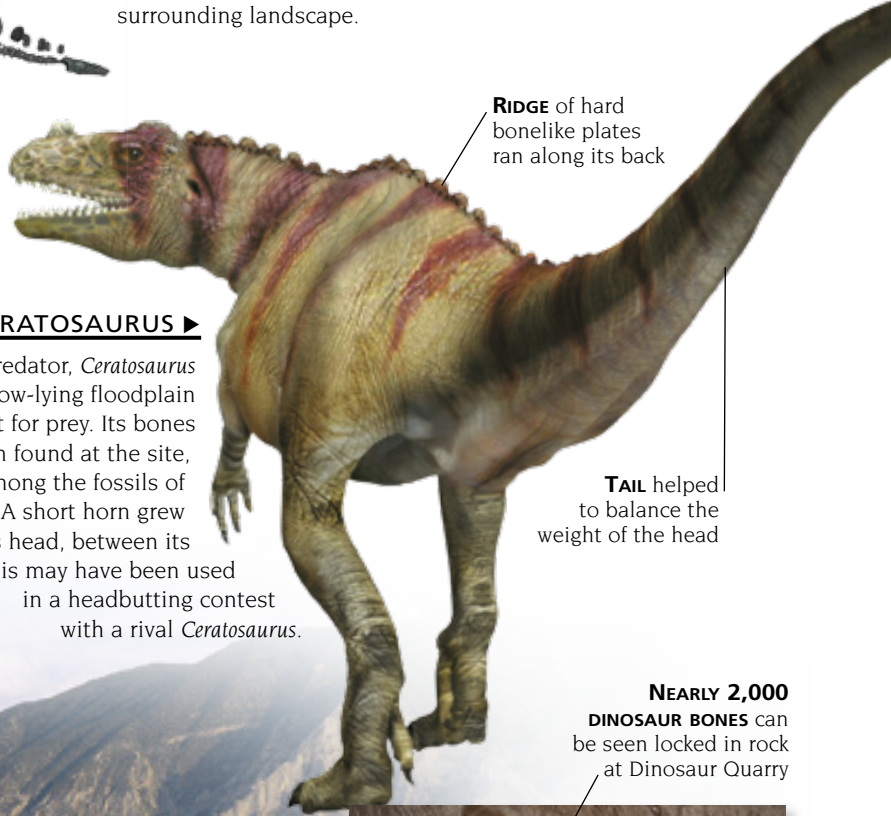
Excavations began in 1909, centered on a site known as Dinosaur Quarry. In 1915 the Dinosaur National Monument was created in recognition of the importance of the surrounding landscape.



NORTH AMERICA

CERATOSAURUS ►

A big predator, *Ceratosaurus* crossed the low-lying floodplain on the hunt for prey. Its bones have been found at the site, mixed among the fossils of herbivores. A short horn grew from its head, between its eyes. This may have been used in a headbutting contest with a rival *Ceratosaurus*.



RIDGE of hard bonelike plates ran along its back

TAIL helped to balance the weight of the head

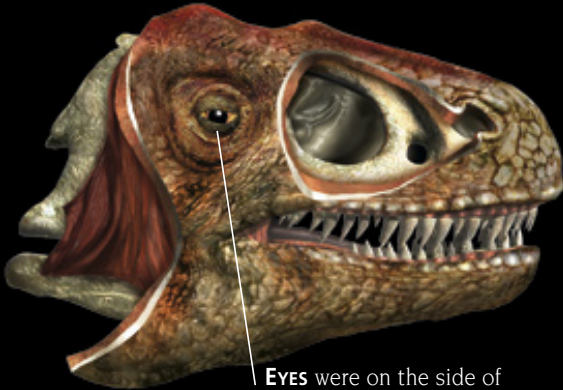
NEARLY 2,000 DINOSAUR BONES can be seen locked in rock at Dinosaur Quarry



HUGE OPENINGS in the skull, which was 1 m (3 ft) long, made it lighter



JAW MUSCLES were powerful, allowing *Allosaurus* to swallow huge mouthfuls of flesh



EYES were on the side of the head, giving *Allosaurus* a wide field of vision

◀ JURASSIC PREDATOR

Several *Allosaurus* have been collected at the Dinosaur National Monument. The largest carnivore of the Jurassic Period, an adult reached lengths of 39 ft (12 m). Its long teeth sliced into flesh then, as it tossed its head from side to side, its powerful jaws tore a chunk from the body of its prey.



TENONTOSAURUS

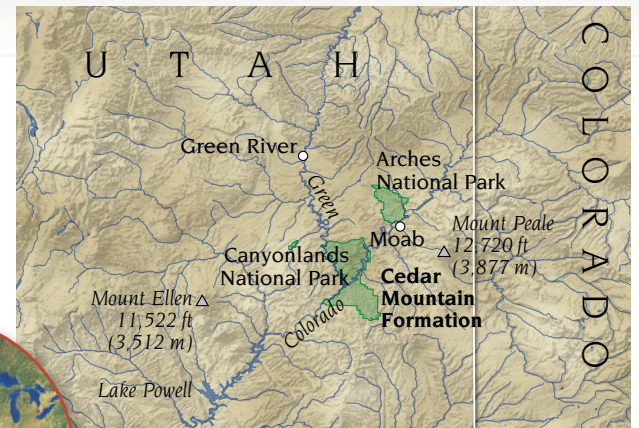
A large animal with a long tail, *Tenontosaurus* resembled *Iguanodon*, which it may be related to. It was a plant-eater that moved on its back legs, but dropped to all-fours when feeding.

Cedar Mountain

ABOUT 110 MILLION YEARS AGO, the states of Utah and Colorado were a forested floodplain dotted with pools and crossed by rivers. There were wet and dry seasons, and after heavy rain the rivers would swell and burst their banks, spilling water filled with muddy sediment across low-lying ground. Many species of dinosaur lived on the plain, including the carnivore *Utahraptor*, and *Gastonia*, an armored dinosaur. Fish, turtles, and crocodiles swam in the rivers and pools. The area's ancient life forms were first recognized in the 1940s, since when the Cedar Mountain Formation has become a major location for the study of Early Cretaceous dinosaurs in North America.

▼ GASTONIA

An early member of the ankylosaur (armored dinosaur) family, *Gastonia*'s neck, back, and tail were covered in wide, flat, bony spines. It was a herbivore that probably grazed on ferns and other ground plants. Many specimens have been found in the rocks of the Cedar Mountain Formation, suggesting it was one of the area's common dinosaurs.



▲ SITE LOCATION

The Early Cretaceous rocks of the Cedar Mountain Formation occur in the southwestern US, in eastern Utah and parts of Colorado. It includes the sandstones of Arches National Park.

LONGEST SPINES were at the shoulders, reaching lengths of 12 in (30 cm) in an adult

DEINONYCHUS

The sharp teeth of *Deinonychus*, a pack-hunting carnivore, have been found among the bones of *Tenontosaurus*. This is evidence for both predator and prey.



TEETH TO PUNCTURE AND PULL

The jaws of *Deinonychus* were packed with backward-slanting teeth. They were sharp, but were not designed to cut through meat. Instead, *Deinonychus* bit into its prey, then jerked its head to tear the flesh away.

DID YOU KNOW?

A bone bed has produced more than 3,000 bones belonging to perhaps 20 *Gastonia* dinosaurs. This suggests the animals lived in a herd that died in a single, sudden catastrophe.

Dinosaur tracks and eggshells are also found in the rocks.

UTAHRAPTOR ▶

The top predator of the Cedar Mountain Formation was probably *Utahraptor*. This dromaeosaur (running lizard), which was the largest member of its group, was armed with a curved claw on each foot that grew to 15 in (38 cm). An intelligent animal, *Utahraptor* may have hunted in packs, stalking prey before attacking it with a combination of flesh-piercing kicks and bites.

TEETH-PACKED JAWS were long and narrow, and were controlled by strong muscles

PART OF A BACKBONE, possibly of *Brachiosaurus*, excavated in the Cedar Mountain Formation



◀ CEDAR MOUNTAIN TODAY

Over a period of perhaps 20 million years, the sediments dropped by the rivers and pools of the Early Cretaceous built up and hardened into deep deposits of rock. Today, these ancient rocks form high cliffs of rust-colored pebbly sandstone, mudstone, and siltstone, which have been eroded by weathering into deep canyons, pinnacles, and arches.

Hell Creek

AS THE MISSOURI RIVER flows through the east of Montana, it cuts into a series of ancient rocks known as the Hell Creek Formation. The deep layers of sandstone, siltstone, and mudstone were formed during the Late Cretaceous Period, about 65 million years ago. At that time the area was a low-lying floodplain crossed by rivers, lying along the coast of a now-vanished sea. Many species of dinosaur and other animals lived and died here. Locked within the rocks of the Hell Creek Formation is one of the world's major dinosaur graveyards. It was here, in 1902, that the first *Tyrannosaurus rex* specimen was found, along with other notable discoveries.



▲ SITE LOCATION

Hell Creek is a vast, arid region in the eastern part of Montana.

TROODON

The creek teemed with small, agile dinosaurs, such as *Troodon*. Armed with keen eyesight and sharp, grasping claws, they were efficient hunters.

TRICERATOPS

Ceratopsians (horned dinosaurs) were the area's most abundant dinosaurs. *Triceratops* was the largest member of the group.

EDMONTOSAURUS

Slow-moving *Edmontosaurus* was a hadrosaur, or duck-billed dinosaur. Many duckbills lived in Hell Creek, feeding on the ample supply of plants.

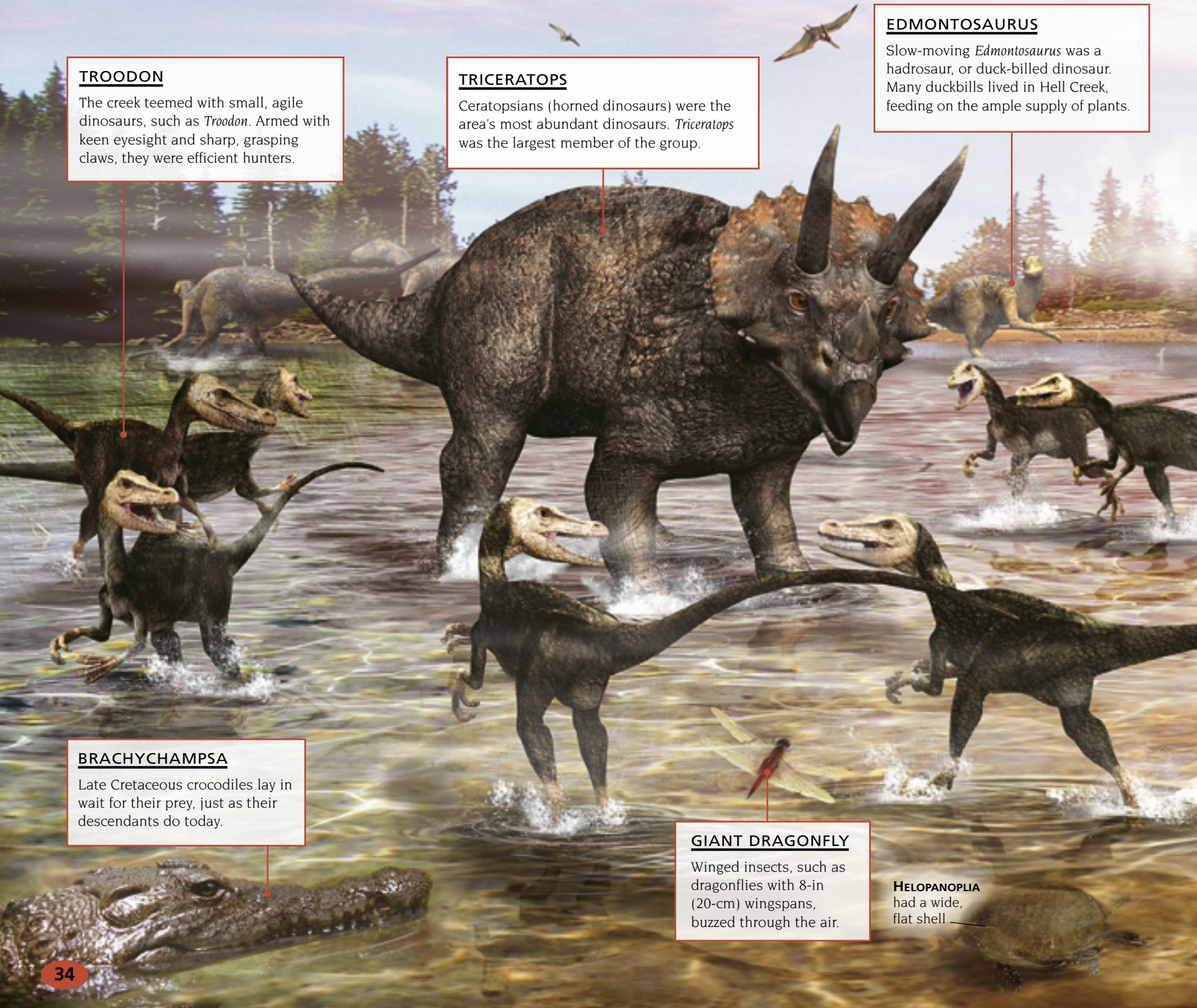
BRACHYCHAMPSA

Late Cretaceous crocodiles lay in wait for their prey, just as their descendants do today.

GIANT DRAGONFLY

Winged insects, such as dragonflies with 8-in (20-cm) wingspans, buzzed through the air.

HELOPANOPLIA
had a wide, flat shell



Barnum Brown



Barnum Brown (1873–1963) began work at The American Museum of Natural History, New York City, in 1898. In 1901 he was shown photographs of dinosaur bones in Montana. The following year he led the first expedition to the region, and discovered the partial skeleton of a new species of large meat-eating dinosaur. In 1905, Brown's dinosaur was named *Tyrannosaurus rex*.

HELL CREEK VEGETATION

Sixty-five million years ago, Hell Creek was a woodland landscape. Trees from the conifer, laurel, sycamore, beech, magnolia, and palm families grew in the moist, humid climate. Mosses grew on the ground, as did ferns. There was no grass, however.

BROAD-LEAVED TREES grew for the first time during this period

TEETH MARKS have been found in the bones of many dinosaurs that inhabited Hell Creek

EDMONTONIA

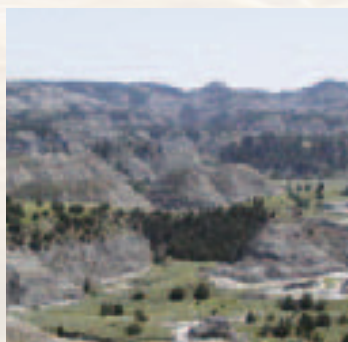
A member of the ankylosaur family, *Edmontonia* was an armored herbivore whose body was covered in bony plates and spikes.

HELOPANOPLIA

Several different kinds of turtle lived in the rivers and streams that crossed the floodplain. They were a good source of food for the predators of the creek.

HELL CREEK TODAY

The soft rocks of Hell Creek have been steadily eroded by the actions of wind, water, and ice, wearing them into the deep canyons and ravines that characterize the area today. Known as "badlands," (because the terrain is bad land to cross over) the dinosaur-bearing rocks lie in thick, horizontal layers. The oldest are at the bottom, and the youngest at the top.



TYRANNOSAURUS

This was the biggest carnivore of the Late Cretaceous, and the top predator in the Hell Creek environment.

South America



UNTIL THE 1950s, dinosaur fossils were rarely found in South America since there was very little research carried out on this continent. Since then, however, extensive fieldwork by teams of paleontologists—and some chance finds by farmers—has revealed dinosaur bones, eggs, and trackways at about 100 sites across the continent. The South American dinosaurs show a close resemblance to those found in North Africa, suggesting that the two continents were still connected during the mid-Cretaceous Period. Many dinosaur fossils have been found in the south, especially in Argentina. Although they cover all periods of dinosaur existence, from the Late Triassic to the Late Cretaceous, to date not many Jurassic fossils have been discovered.

EORAPTOR



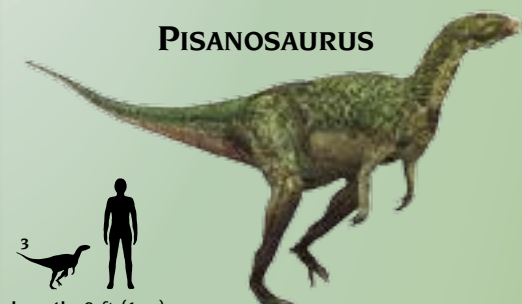
1
Length: 3 ft (1 m)
Pronunciation: ee-oh-rap-tor
Meaning: "early plunderer"

HERRERASAURUS



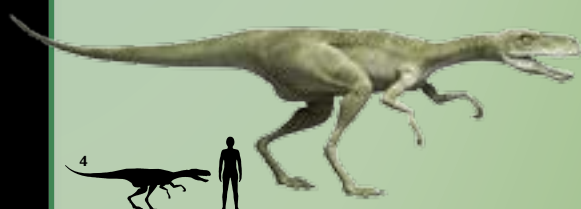
2
Length: 9 ft (3 m)
Pronunciation: herr-ray-ra-sore-us
Meaning: "Herrera's lizard"

PISANOSAURUS



3
Length: 3 ft (1 m)
Pronunciation: pie-zan-oh-sore-us
Meaning: "Pisano's lizard" (after paleontologist Juan Pisano)

STAUROSAURUS



4
Length: 6½ ft (2 m)
Pronunciation: store-ee-koh-sore-us
Meaning: "Southern Cross lizard"

ANGATURAMA



5
Length: 16 ft (5 m)
Pronunciation: ahn-gah-two-rah-ma
Meaning: "noble one"

AUCASAURUS



6
Length: 13 ft (4 m)
Pronunciation: ow-kuh-sore-us
Meaning: "Auca lizard"

CARNOTAURUS



7
Length: 9 ft (3 m)
Pronunciation: kar-noh-tore-us
Meaning: "flesh bull"

GIGANOTOSAURUS



8
Length: 43 ft (13 m)
Pronunciation: jig-an-o-toe-sore-us
Meaning: "giant southern lizard"

MIRISCHIA



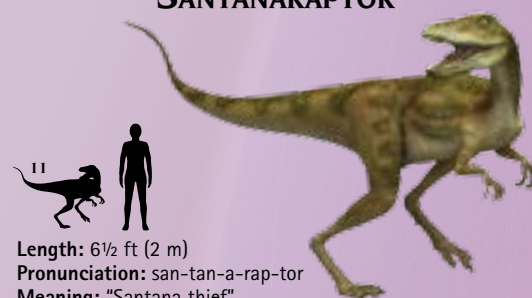
9
Length: 6½ ft (2 m)
Pronunciation: meer-iss-chee-a
Meaning: "wonderful pelvis"

IRRITATOR



10
Length: 26 ft (8 m)
Pronunciation: ear-ih-tay-tor
Meaning: "irritation"

SANTANARAPTOR



11
Length: 6½ ft (2 m)
Pronunciation: san-tan-a-rap-tor
Meaning: "Santana thief"

SALTASAURUS



12
Length: 39 ft (12 m)
Pronunciation: salt-a-sore-us
Meaning: "Salta lizard"

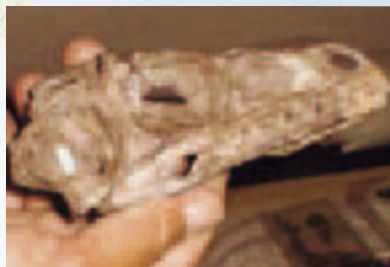
THE MAP

Some of South America's major dinosaur locations are shown on this map, together with the dinosaurs found there.



VALLEY OF THE MOON

The Late Triassic sandstones of northwest Argentina contain the oldest, well-preserved dinosaur fossils found anywhere in the world. Pictured here is the tiny skull of *Eoraptor*. It was the smallest dinosaur in the Valley of the Moon.



ARARIPE BASIN

At this location, in eastern Brazil, the Early Cretaceous limestone of the Santana Formation is a window on the world of 100 million years ago, revealing an abundance of fish fossils (shown above), together with the carnivorous dinosaurs that feasted upon them.



PIATNITZKYSAURUS

A meat-eater from the Middle Jurassic, about 163 million years ago, this dinosaur has been found in southern Argentina, where it may have hunted the area's sauropods. It is one of the few Jurassic dinosaurs to have been discovered so far.



KEY



TRIASSIC PERIOD



CRETACEOUS PERIOD



SITE

Valley of the Moon



▲ SITE LOCATION

Ischigualasto National Park covers 156,000 acres (63,000 hectares).



SOME OF THE WORLD’S OLDEST DINOSAURS are found in the Ischigualasto National Park of northwestern Argentina, an area also known as the Valley of the Moon. A deposit of sandstones and mudstones, it formed about 225 million years ago, when the region was a lush floodplain at the edge of the Pangaea supercontinent. *Eoraptor*, *Herrerasaurus* and other early dinosaurs lived in the Late Triassic warm environment. Today, the landscape is a dry and barren desert.

STAURIKOSAURUS

A lightweight carnivore, *Staurikosaurus* was an agile hunter. It had a long tail, grasping hands with sharp claws, and many small, biting teeth set into its long jaws.

SCORPION

These scorpions thrived in the warmth and were part of the food chain for the region’s carnivores.

MILLIPEDE

Giant millipedes, some up to 5 ft (1.5 m) long, snaked their way through the forest.

HORSETAILS

Tall, straight horsetails thrived in the damp conditions. With jointed stems and short leaves, these plants were a vital source of food for herbivores.

DID YOU KNOW?

▶ *Herrerasaurus* was named after Victorino Herrera, an Argentinian farmer who discovered it in 1958.

TODAY'S LANDSCAPE

The swamps and forests of the Late Triassic are now the rugged, moonlike landscape of the Ischigualasto region. It is a desert zone, that lies, on average, 4,000 ft (1,200 m) above sea level, with little rainfall and sparse vegetation. Stream beds are dry for much of the time, but when rain does fall they quickly fill and flash floods can occur. Since 1971, much of the area has been a national park.



LUSH FOREST

More than 100 different plant species have been identified, from ground-covering ferns and horsetails to trees that towered 131 ft (40 m) above them.

HERRERASAURUS

One of the largest hunters of the time, *Herrerasaurus* was a sharp-eyed predator whose backward-pointing teeth pulled flesh from its prey.

EORAPTOR

In the Triassic forests of Argentina lived the tiny *Eoraptor*—a predatory animal that hunted lizards and small mammal-like creatures. It was one of the first carnivorous dinosaurs.

PISANOSAURUS

About the size of a sheep, *Pisanosaurus* was a plant-eater. It ate low-growing plants, which it nipped with sharp teeth at the front of its mouth.

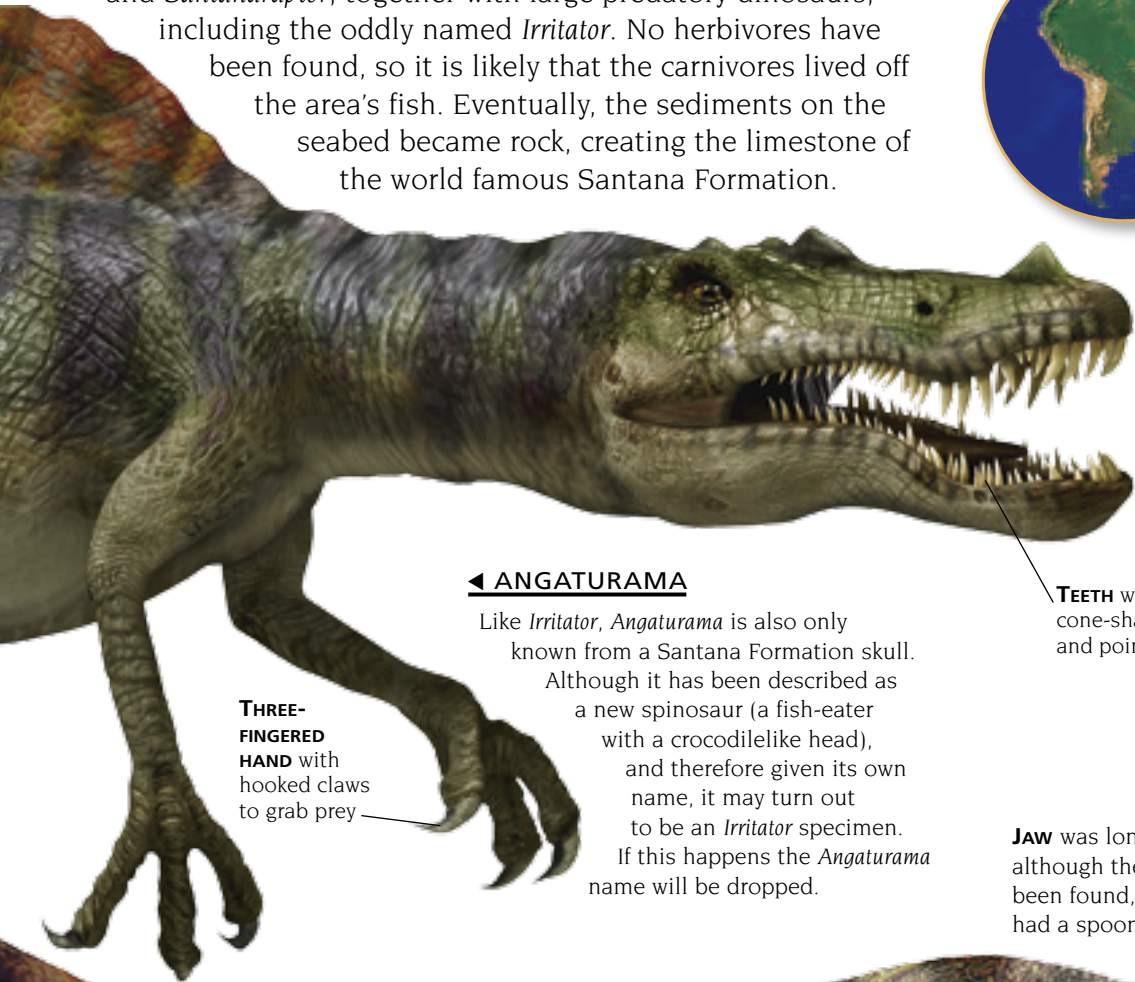
Araripe Basin

Fossils from the early Cretaceous, about 100 million years ago, have been discovered in Brazil's Araripe Basin. At this time, South America lay close to Africa, but as the continents edged apart an inland sea formed. Along its edges lived small carnivores, such as *Mirischia* and *Santanaraptor*, together with large predatory dinosaurs, including the oddly named *Irritator*. No herbivores have been found, so it is likely that the carnivores lived off the area's fish. Eventually, the sediments on the seabed became rock, creating the limestone of the world famous Santana Formation.



▲ SITE LOCATION

The Araripe Basin is in northeast Brazil, and covers about 3,000 sq miles (8,000 sq km). The Santana Formation lies within the Araripe Basin.



◀ ANGATURAMA

Like *Irritator*, *Angaturama* is also only known from a Santana Formation skull. Although it has been described as a new spinosaur (a fish-eater with a crocodilelike head), and therefore given its own name, it may turn out to be an *Irritator* specimen. If this happens the *Angaturama* name will be dropped.

THREE-FINGERED HAND with hooked claws to grab prey

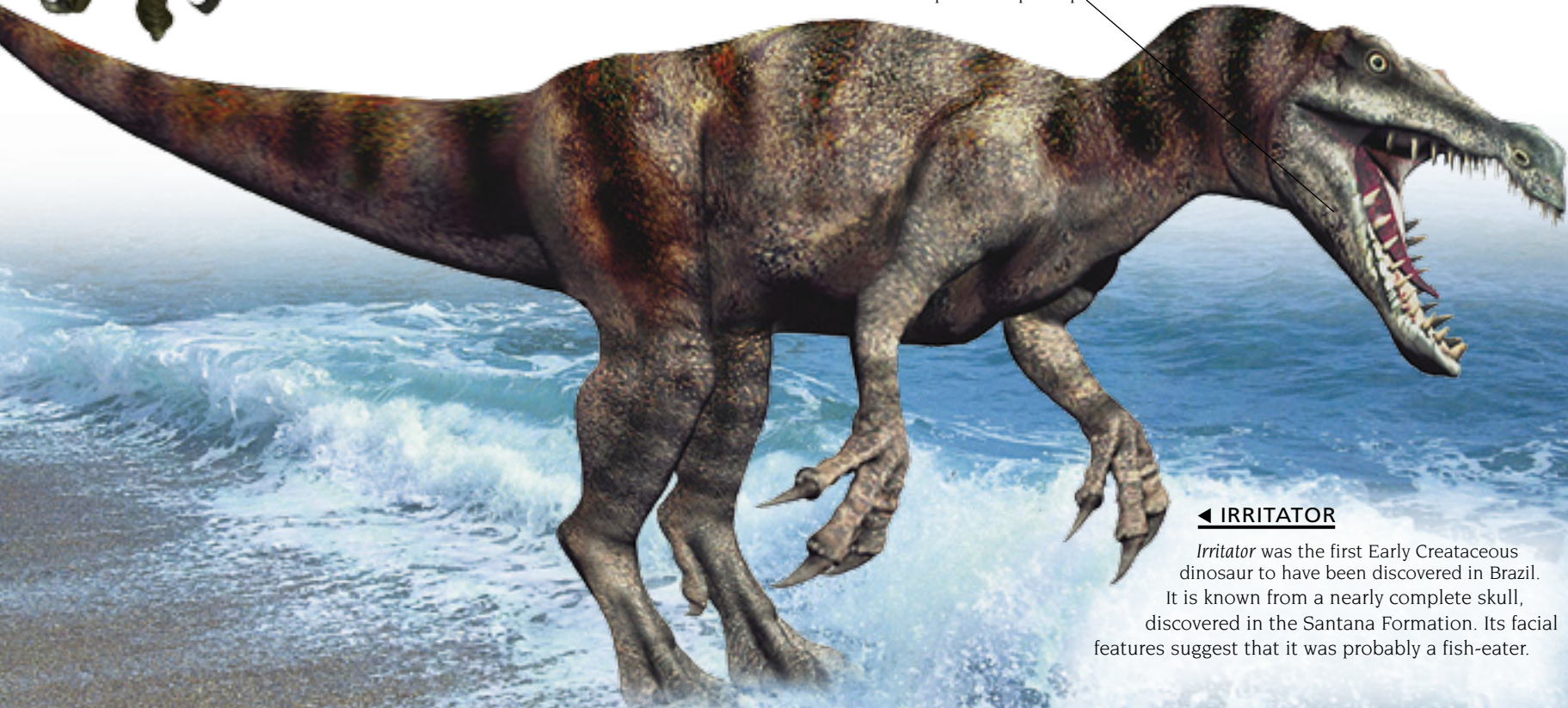
TEETH were cone-shaped and pointed



▲ FOSSILIZED DRAGONFLY

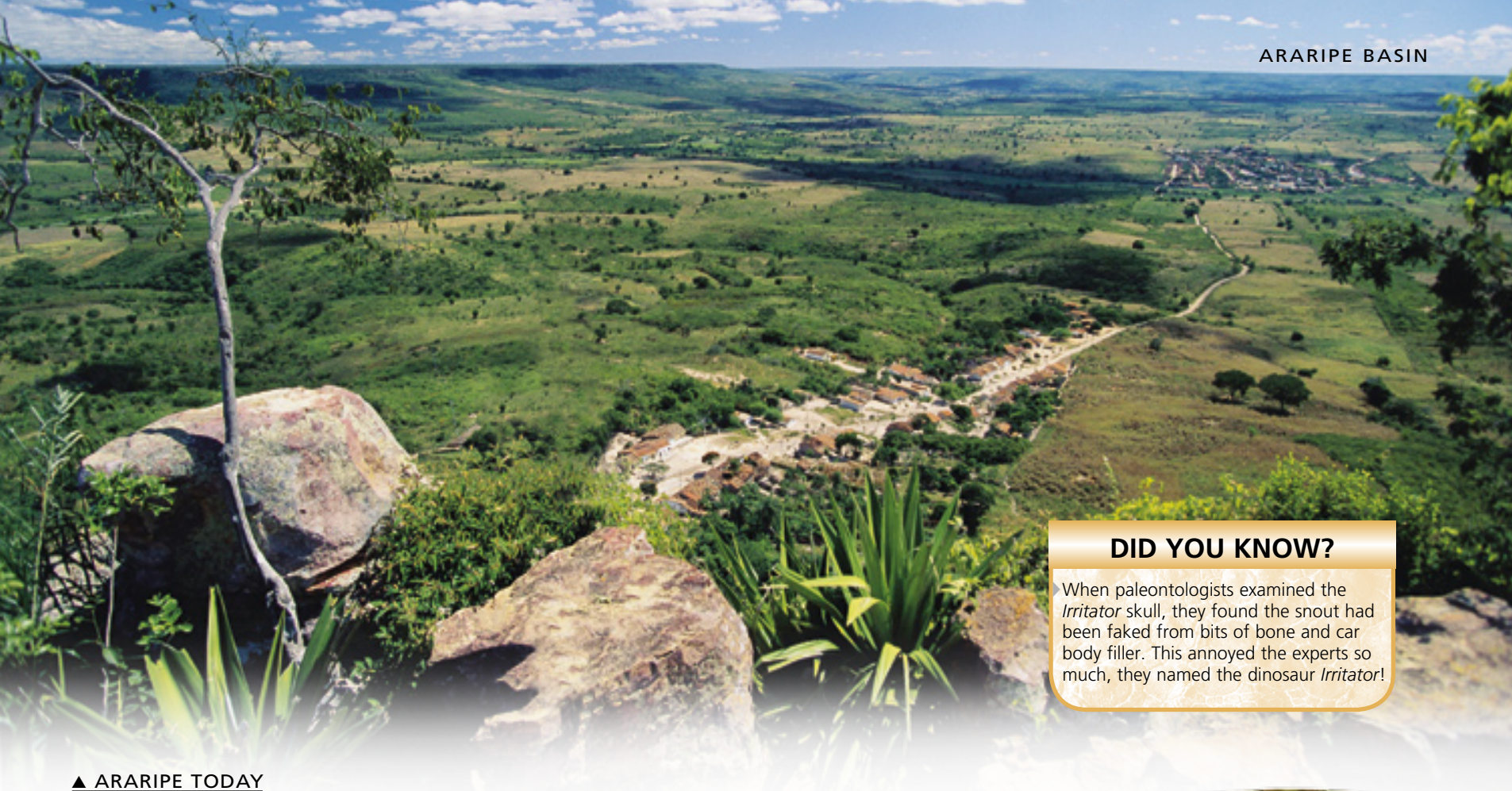
Fossils of invertebrates (animals without backbones), particularly insects, are preserved in great detail, such as this *Zygoptera* dragonfly.

JAW was long and slim, and although the snout has not been found, it may have had a spoon-shaped tip



◀ IRRITATOR

Irritator was the first Early Cretaceous dinosaur to have been discovered in Brazil. It is known from a nearly complete skull, discovered in the Santana Formation. Its facial features suggest that it was probably a fish-eater.

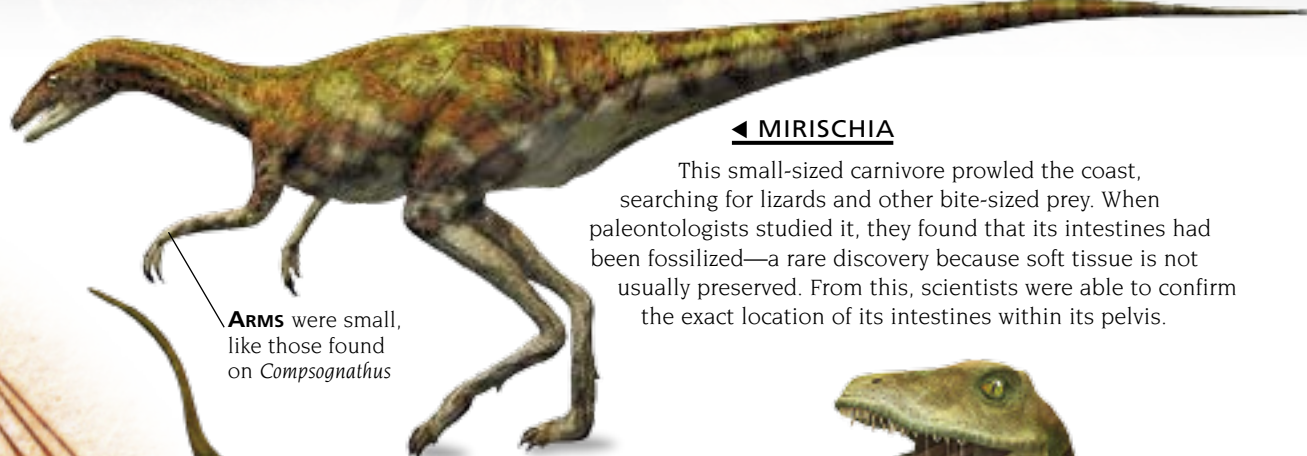


DID YOU KNOW?

When paleontologists examined the *Irritator* skull, they found the snout had been faked from bits of bone and car body filler. This annoyed the experts so much, they named the dinosaur *Irritator*!

▲ ARARIPE TODAY

The greater part of the Araripe Basin lies in the south of the Brazilian state of Ceará. It is an area of fertile soil, where small, thorny trees, cacti, and grasses grow. There are plans to make the area into a National Geopark, which would help to protect the area's environment and its unique fossils.



◀ MIRISCHIA

This small-sized carnivore prowled the coast, searching for lizards and other bite-sized prey. When paleontologists studied it, they found that its intestines had been fossilized—a rare discovery because soft tissue is not usually preserved. From this, scientists were able to confirm the exact location of its intestines within its pelvis.

ARMS were small, like those found on *Compsognathus*



LEGS are still attached to the thorax (chest region)

◀ FOSSILIZED CRANE FLY

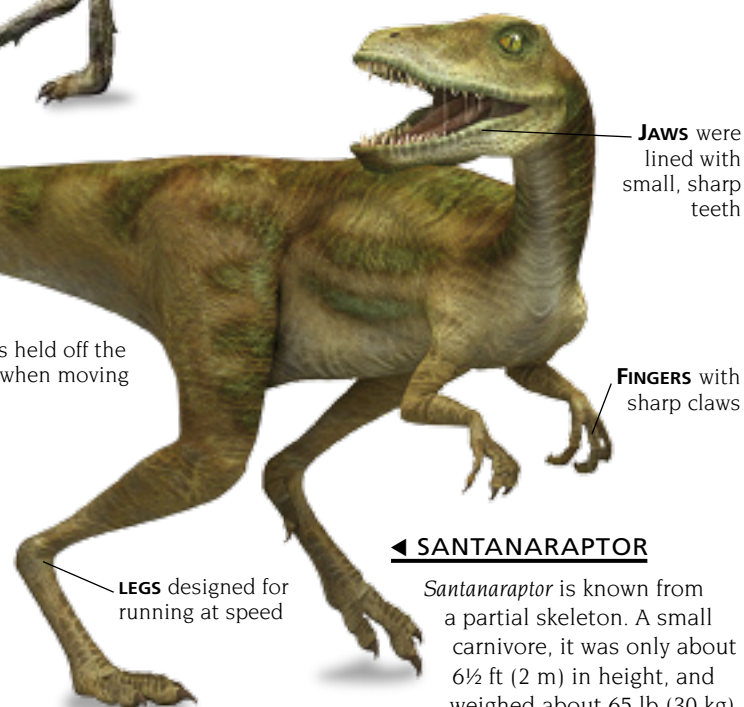
Altogether, more than 200 different Cretaceous insect species have been identified from the Araripe Basin, including this crane fly (known as *tipulid*).

FOSSILIZED FISH ▶

Fish are the most famous fossils from the Santana Formation. Even their eyes, muscles, and intestines are well preserved, along with their bones.



TAIL was held off the ground when moving



JAWS were lined with small, sharp teeth

FINGERS with sharp claws

LEGS designed for running at speed

◀ SANTANARAPTOR

Santanaraptor is known from a partial skeleton. A small carnivore, it was only about 6½ ft (2 m) in height, and weighed about 65 lb (30 kg).

Impressions of its skin were also found, and holes within its bones reveal the positions of blood vessels.

Auca Mahuevo

THE SOUTHERN PART OF SOUTH AMERICA, known as Patagonia, is an area of dry, rocky desert, spanning Argentina and Chile. At Auca Mahuevo there is a spectacular dinosaur nesting site, where the desert surface is littered with the eggs of Late Cretaceous sauropods (huge plant-eating dinosaurs), laid 80 million years ago. Ancient Patagonia was also the home of predators, including the formidable *Giganotosaurus* and the smaller *Aucasaurus*—a dangerous visitor that may have fed on the defenseless Auca Mahuevo hatchlings.



THE LANDSCAPE TODAY

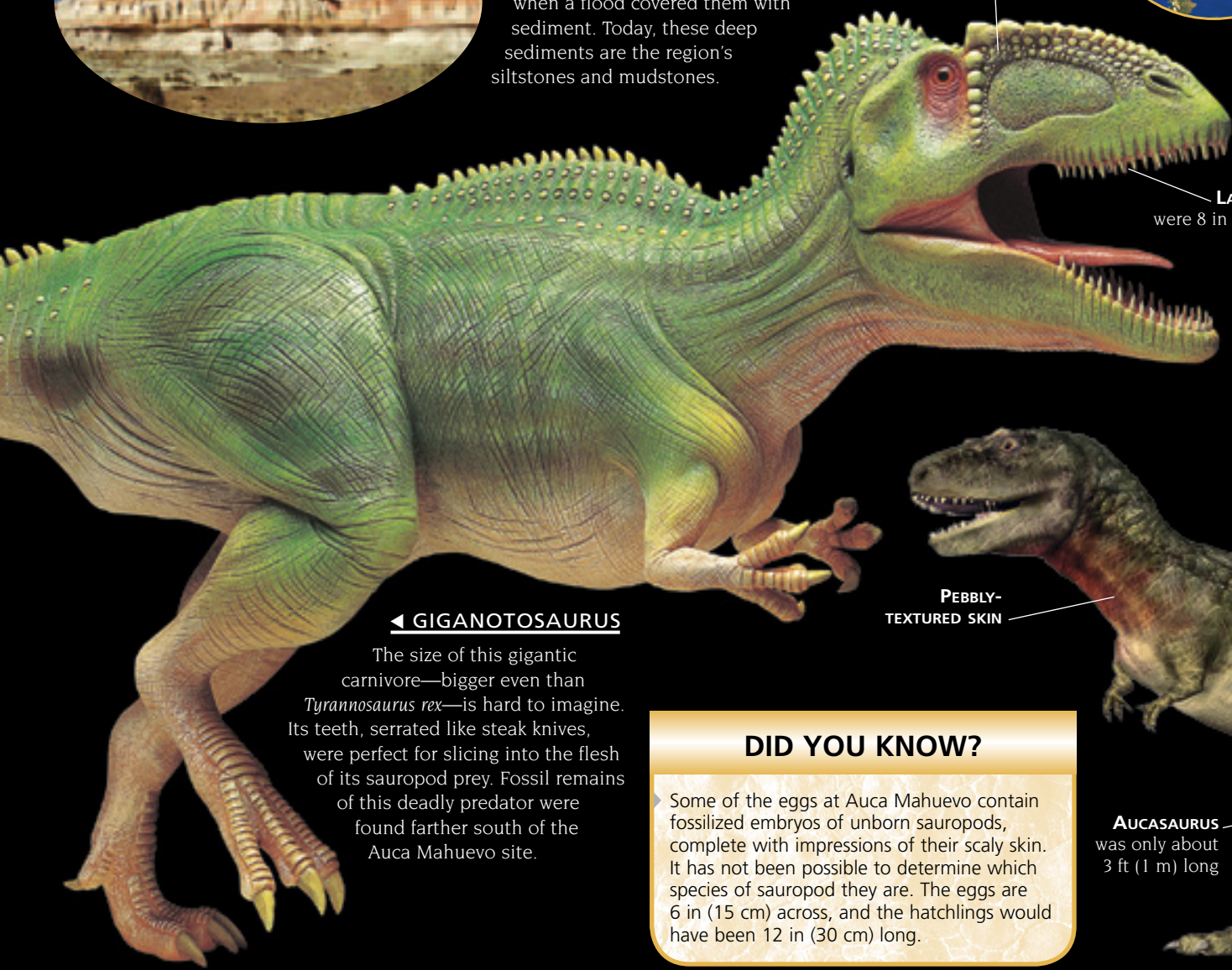
Auca Mahuevo was once a river floodplain. Sauropods laid their eggs on the ground, then lost them when a flood covered them with sediment. Today, these deep sediments are the region's siltstones and mudstones.

HEAD was 6 ft (1.8 m) long



SITE LOCATION

The Auca Mahuevo nesting site is in Neuquén Province, western Argentina. Some of the largest dinosaur fossils have also been found in this province.



GIGANOTOSAURUS

The size of this gigantic carnivore—bigger even than *Tyrannosaurus rex*—is hard to imagine. Its teeth, serrated like steak knives, were perfect for slicing into the flesh of its sauropod prey. Fossil remains of this deadly predator were found farther south of the Auca Mahuevo site.

PEBBLY-TEXTURED SKIN

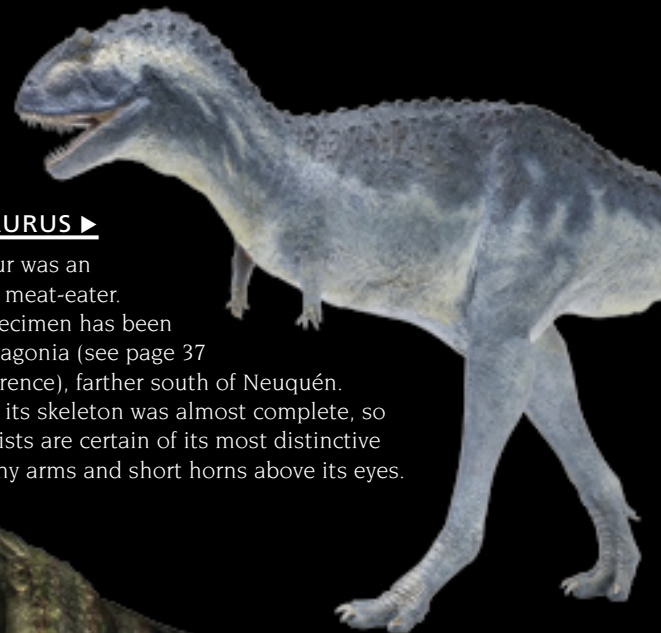
DID YOU KNOW?

Some of the eggs at Auca Mahuevo contain fossilized embryos of unborn sauropods, complete with impressions of their scaly skin. It has not been possible to determine which species of sauropod they are. The eggs are 6 in (15 cm) across, and the hatchlings would have been 12 in (30 cm) long.

LARGEST TEETH were 8 in (20 cm) long

CARNOTAURUS

This dinosaur was an odd-looking meat-eater. Only one specimen has been found in Patagonia (see page 37 for map reference), farther south of Neuquén. Remarkably, its skeleton was almost complete, so paleontologists are certain of its most distinctive features—tiny arms and short horns above its eyes.



AUCASAURUS

Like *Carnotaurus*, *Aucasaurus* also had very short arms, but instead of horns, bumps grew over its eyes. The only known example seems to have died from head injuries, possibly inflicted in a fight.

AUCASAURUS was only about 3 ft (1 m) long

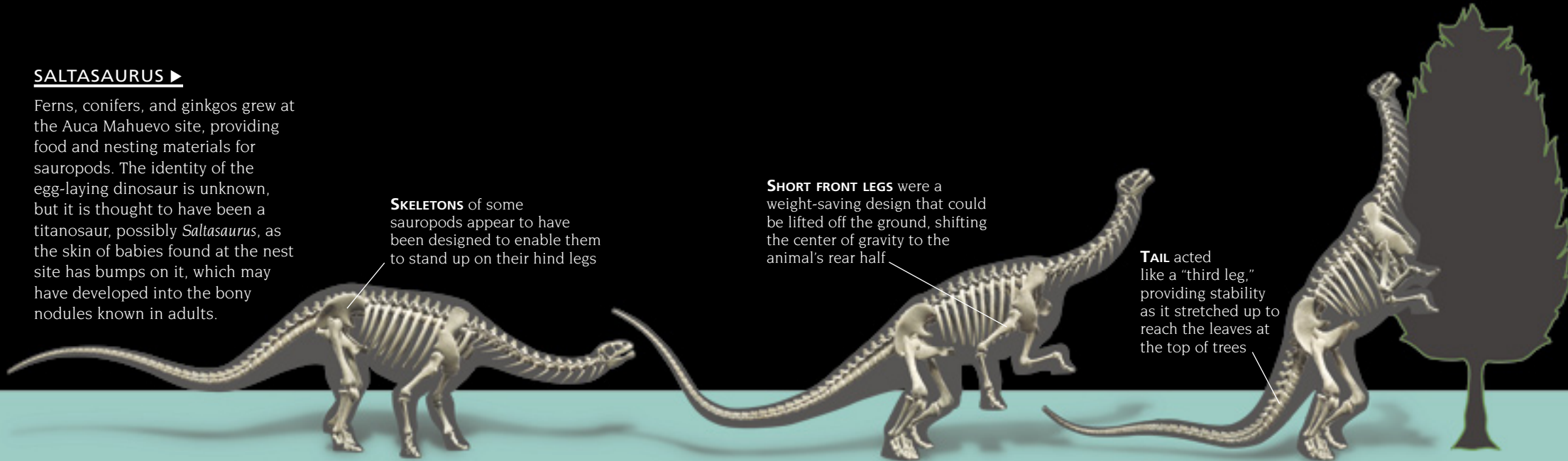
SALTASAURUS

Ferns, conifers, and ginkgos grew at the Auca Mahuevo site, providing food and nesting materials for sauropods. The identity of the egg-laying dinosaur is unknown, but it is thought to have been a titanosaur, possibly *Saltasaurus*, as the skin of babies found at the nest site has bumps on it, which may have developed into the bony nodules known in adults.

SKELTONS of some sauropods appear to have been designed to enable them to stand up on their hind legs

SHORT FRONT LEGS were a weight-saving design that could be lifted off the ground, shifting the center of gravity to the animal's rear half

TAIL acted like a "third leg," providing stability as it stretched up to reach the leaves at the top of trees



Europe



THE DINOSAURS OF EUROPE are currently known from about 375 different locations across the continent. They range in date from the Late Triassic of 225 million years ago to the Late Cretaceous, 65 million years ago. It was in Europe that the curiosity in ancient animal bones first began, and the earliest scientific studies and naming of dinosaurs were carried out here. About 80 dinosaur species have so far been identified in the countries of Europe, from small carnivores to the giant plant-eaters of the Jurassic. In addition to dinosaurs, Europe's rocks contain other fossils, including a primitive bird and many kinds of pterosaur. All together they reveal just how varied the ancient animal kingdom was.

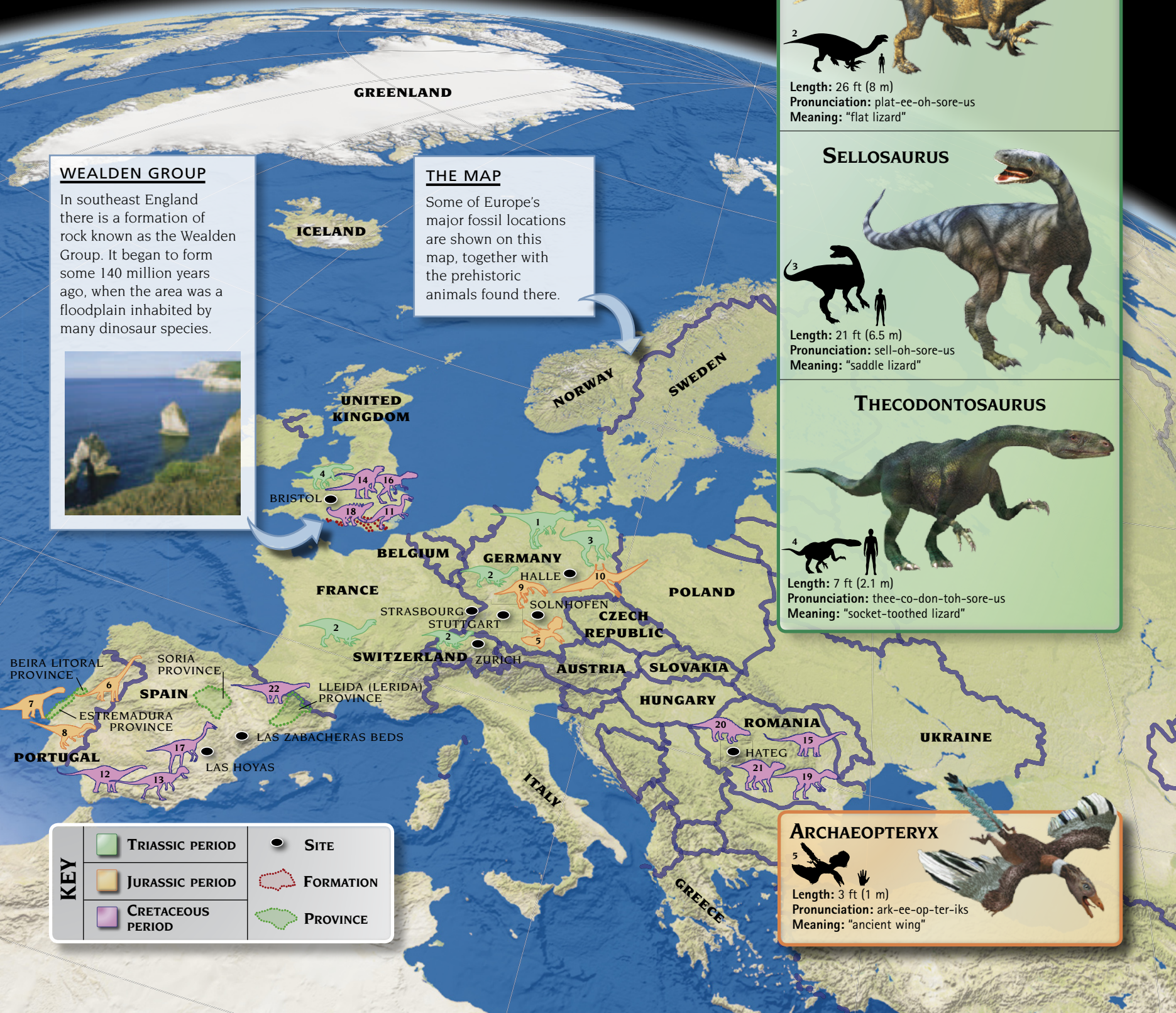
WEALDEN GROUP

In southeast England there is a formation of rock known as the Wealden Group. It began to form some 140 million years ago, when the area was a floodplain inhabited by many dinosaur species.



THE MAP

Some of Europe's major fossil locations are shown on this map, together with the prehistoric animals found there.



KEY



TRIASSIC PERIOD



JURASSIC PERIOD



CRETACEOUS PERIOD

● SITE

FORMATION

PROVINCE

LILIENSTERNUS



Length: 20 ft (6 m)

Pronunciation: lil-ee-an-ster-nus

Meaning: named after a paleontologist, Ruhle von Lilienstern

PLATEOSAURUS

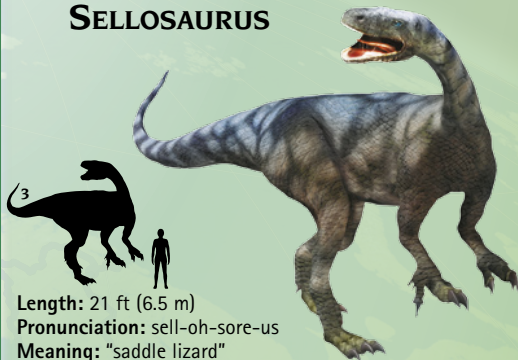


Length: 26 ft (8 m)

Pronunciation: plat-ee-oh-sore-us

Meaning: "flat lizard"

SELLOSARUS



Length: 21 ft (6.5 m)

Pronunciation: sell-oh-sore-us

Meaning: "saddle lizard"

THECODONTOSAURUS



Length: 7 ft (2.1 m)

Pronunciation: thee-co-don-toh-sore-us

Meaning: "socket-toothed lizard"

ARCHAEOPTERYX



Length: 3 ft (1 m)

Pronunciation: ark-ee-op-ter-iks

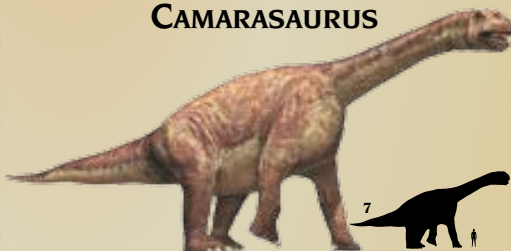
Meaning: "ancient wing"

BRACHIOSAURUS



Length: 50 ft (16 m)
Pronunciation: brak-ee-oh-sore-us
Meaning: "arm lizard"

CAMARASAURUS



Length: 75 ft (23 m)
Pronunciation: kam-are-ah-sore-us
Meaning: "chambered lizard"

CAMPTOSAURUS



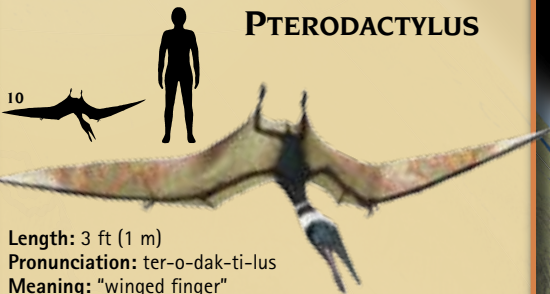
Length: 23 ft (7 m)
Pronunciation: kamp-toe-sore-us
Meaning: "bent lizard"

COMPSOGNATHUS



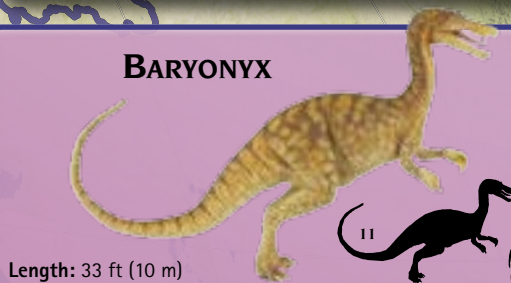
Length: 3 ft (1 m)
Pronunciation: comp-sog-nath-us
Meaning: "pretty jaw"

PTERODACTYLUS



Length: 3 ft (1 m)
Pronunciation: ter-o-dak-ti-lus
Meaning: "winged finger"

BARYONYX



Length: 33 ft (10 m)
Pronunciation: bar-ee-on-iks
Meaning: "heavy claw"

HYPSELOSAURUS



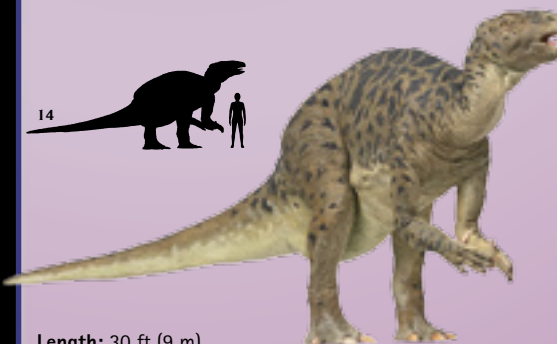
Length: 39 ft (12 m)
Pronunciation: hip-sell-oh-sore-us
Meaning: "high-ridged lizard"

HYPSILOPHODON



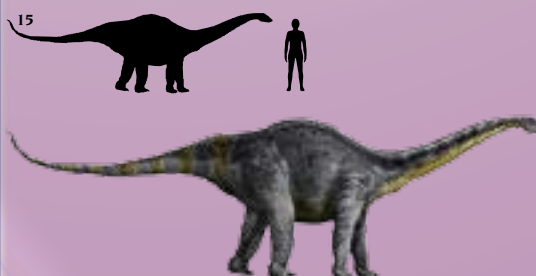
Length: 6½ ft (2 m)
Pronunciation: hip-sill-oh-fo-don
Meaning: "high-ridged tooth"

IGUANODON



Length: 30 ft (9 m)
Pronunciation: ig-wha-noh-don
Meaning: "iguana tooth"

MAGYAROSAURUS



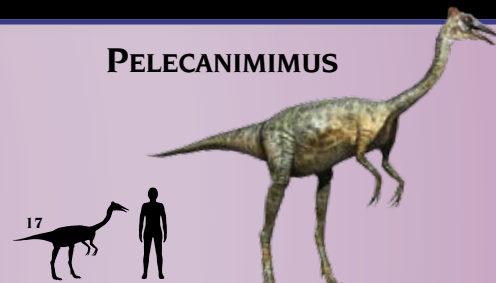
Length: 17 ft (5.3 m)
Pronunciation: mag-yar-oh-sore-us
Meaning: "Magyar lizard"

NEOVENATOR



Length: 33 ft (10 m)
Pronunciation: nee-o-ven-a-tor
Meaning: "new hunter"

PELECANIMIMUS



Length: 6½ ft (2 m)
Pronunciation: pel-ih-can-ih-mime-us
Meaning: "pelican mimic"

POLACANTHUS



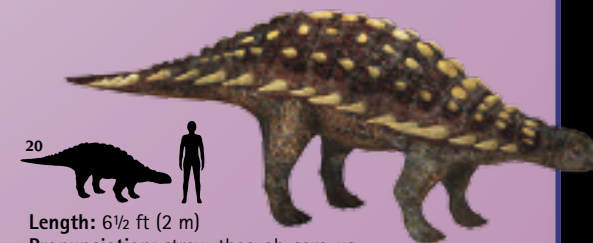
Length: 16 ft (5 m)
Pronunciation: pol-a-kan-thus
Meaning: "many spines"

RHABDODON



Length: 15 ft (4.7 m)
Pronunciation: rab-doh-don
Meaning: "rod tooth"

STRUTHIOSAURUS



Length: 6½ ft (2 m)
Pronunciation: strew-thee-oh-sore-us
Meaning: "ostrich lizard"

TELMATOSAURUS



Length: 17 ft (5 m)
Pronunciation: tell-mat-oh-sore-us
Meaning: "marsh lizard"

TITANOSAURUS



Length: 58 ft (18 m)
Pronunciation: ti-tan-oh-sore-us
Meaning: "titanic lizard"

Europe's First Dinosaurs

THE FIRST DINOSAURS to wander across Europe appeared in the Late Triassic, about 225 million years ago. At this time, Europe was at the northern edge of the Pangaea supercontinent, lying close to the equator. The temperature was high and the environment dry. In the north coastal zone conditions were more suitable for plants and animals, and it was here that *Plateosaurus* and other herbivores lived, feeding on the region's ginkgoes and other vegetation. There were also early meat-eaters, such as *Liliensternus*. These primitive dinosaurs were ancestors of the more advanced species that came after them in later periods.



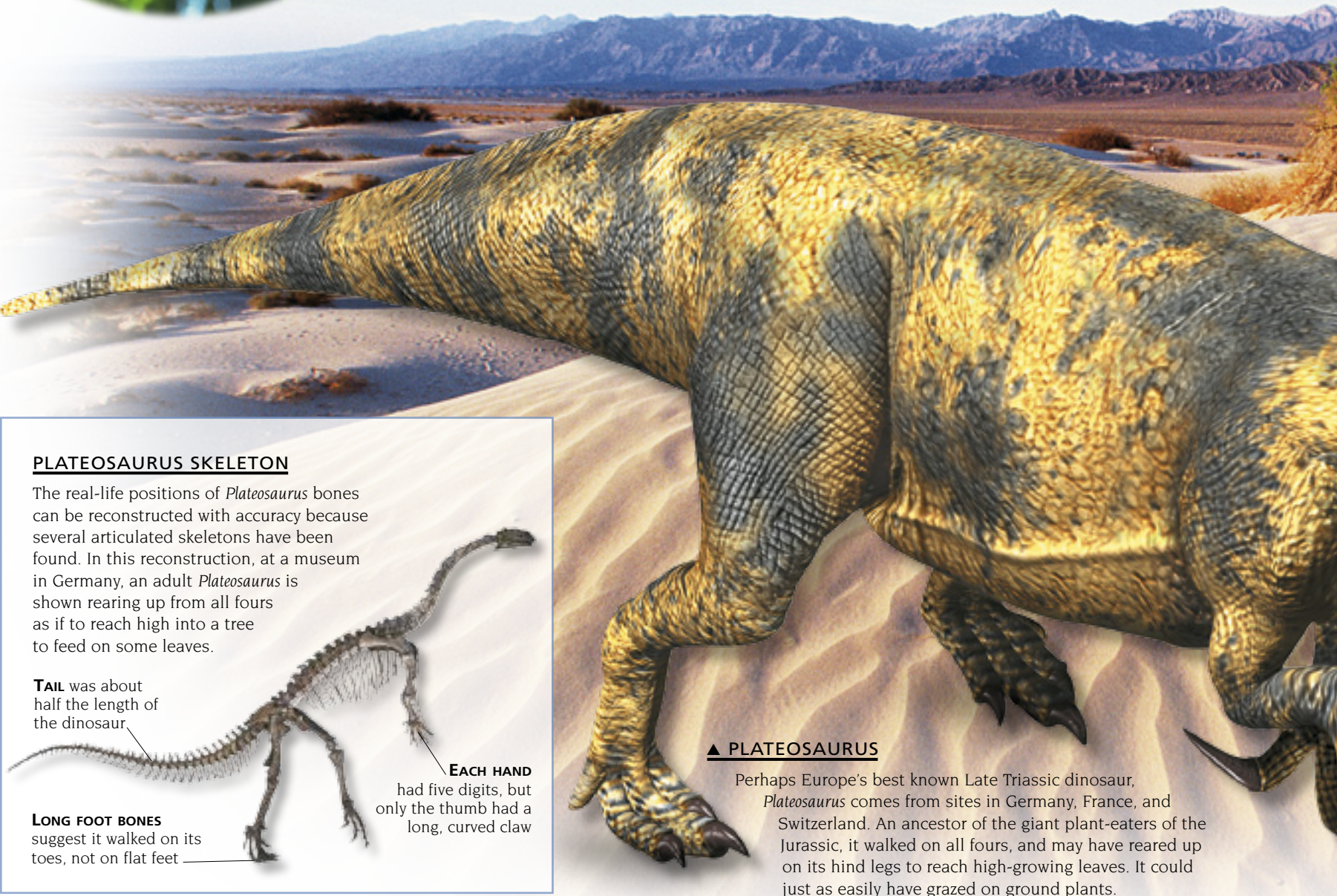
◀ GINKGO

The ginkgo, which is also known as the maidenhair tree, is a "living fossil" that can be seen growing today. Its ancestors first appeared some 270 million years ago, and fossils of their fan-shaped leaves are found in many parts of the world.



▲ SITE LOCATION

More than 50 European locations have produced Late Triassic dinosaur fossils. Many of these sites are concentrated in Germany and France, where ancient rocks once formed the northern edge of the Pangaea supercontinent.



PLATEOSAURUS SKELETON

The real-life positions of *Plateosaurus* bones can be reconstructed with accuracy because several articulated skeletons have been found. In this reconstruction, at a museum in Germany, an adult *Plateosaurus* is shown rearing up from all fours as if to reach high into a tree to feed on some leaves.

TAIL was about half the length of the dinosaur

LONG FOOT BONES suggest it walked on its toes, not on flat feet

EACH HAND had five digits, but only the thumb had a long, curved claw

▲ PLATEOSAURUS

Perhaps Europe's best known Late Triassic dinosaur, *Plateosaurus* comes from sites in Germany, France, and Switzerland. An ancestor of the giant plant-eaters of the Jurassic, it walked on all fours, and may have reared up on its hind legs to reach high-growing leaves. It could just as easily have grazed on ground plants.

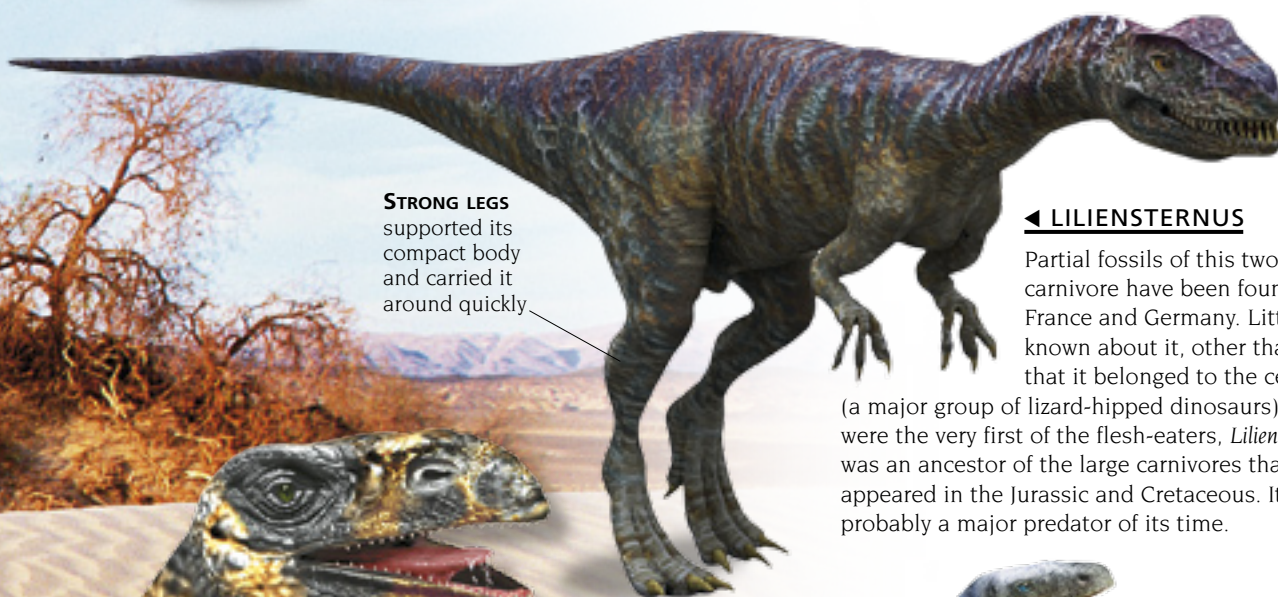
TAIL, which was held off the ground when it walked, was used as a support when *Thecodontosaurus* stretched up



EACH FOOT had four toes with sharp, pointed claws

◀ THECODONTOSAURUS

Discovered in southwest England, *Thecodontosaurus* belonged to the prosauropods (an early plant-eating group of dinosaurs), just like *Plateosaurus*, though about a quarter of its size. Able to walk on its hind legs, as well as on all fours, *Thecodontosaurus* may have used its long thumb claws to hook plants, then pull them toward its mouth. It had spoon-shaped cheek teeth with serrated edges, which were ideal for stripping leaves from ginkgoes and other Triassic trees.



STRONG LEGS supported its compact body and carried it around quickly

◀ LILIENSTERNUS

Partial fossils of this two-legged carnivore have been found in France and Germany. Little is known about it, other than the fact that it belonged to the ceratosaurs (a major group of lizard-hipped dinosaurs). As these were the very first of the flesh-eaters, *Liliensternus* was an ancestor of the large carnivores that appeared in the Jurassic and Cretaceous. It was probably a major predator of its time.



SMALL HEAD had jaws packed with flat-sided leaf-shaped teeth

SELLOSAURUS ▶

A prosauropod from Germany, where its incomplete remains have been found, *Selloosaurus* was a lightly built dinosaur. Like other members of its group, it could move on two legs or four and graze on low-growing plants as well as tree leaves that it stretched up to reach.

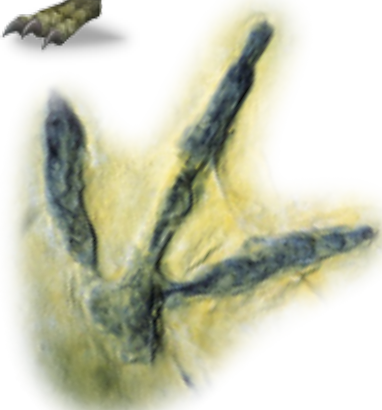


DID YOU KNOW?

▶ *Thecodontosaurus* was discovered in 1834, in a limestone quarry at Bristol, England. When it was described in 1836, it became the very first Triassic dinosaur given a name. Unfortunately, the bones were destroyed when Bristol City Museum was bombed in World War II. Luckily, new bones were found in 1975.

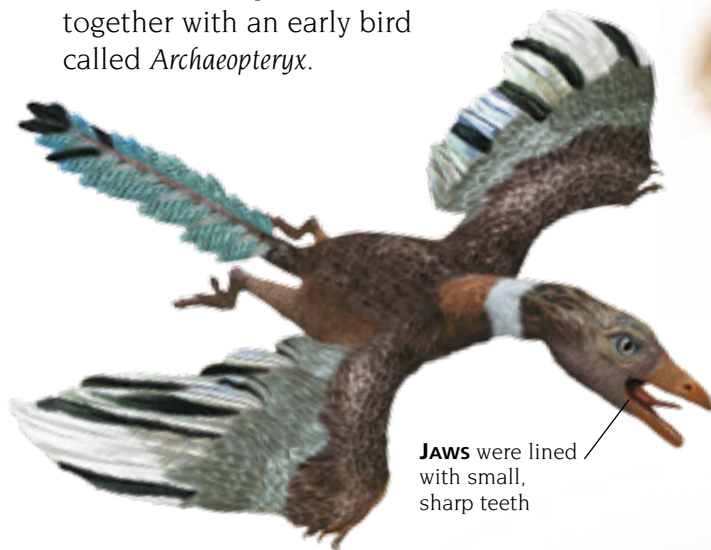
FOOTPRINT ▶

Trace fossils, such as footprints and trackways, have been found in the Late Triassic rocks of Europe. They cannot be linked to individual species, but it is thought many belong to carnivores. Triassic meat-eaters are rarely found, so footprints are evidence for their existence and distribution.



Solnhofen

IN THE LATE JURASSIC of 150 million years ago, the southern region of Germany lay near the Tethys Ocean. Away from the coast were lagoons of still water, and between them were islands on which dinosaurs lived. But it is not land-living reptiles for which this lost world is famous, as they are rarely found. When the waters of the lagoons dried up, and their muddy sediments turned into limestone, it preserved the bodies of flying reptiles that had sunk to the bottom. As the limestone quarries of Solnhofen were opened up, more than 1,000 of these pterosaurs were revealed, together with an early bird called *Archaeopteryx*.



▲ ARCHAEOPTERYX

This primitive bird flapped its feathered wings over land and water. When not airborne, *Archaeopteryx* lived on the ground. Its toes were not designed for perching, so it is unlikely to have spent much time in trees. Related to small-sized meat-eating dinosaurs, *Archaeopteryx* may have been a predator, too.

▲ ARCHAEOPTERYX FOSSIL

Fossils of *Archaeopteryx* are known only from Solnhofen. The first were found in the 1860s, and a total of nine specimens are now in existence. The fine grain of the limestone has preserved their bones and feathers in great detail.



▲ SITE LOCATION

Solnhofen is a town in Bavaria, southern Germany. It gives its name to the limestone found in its vicinity, which began to form in Jurassic times when the area was below water.



▲ SOLNHOFEN LIMESTONE

The limestone from Solnhofen is fine-grained, smooth, and pure. It is these qualities that led to it being quarried from the 1800s onward, and quarry workers were the first to see the fossils of ancient animals within the stone.

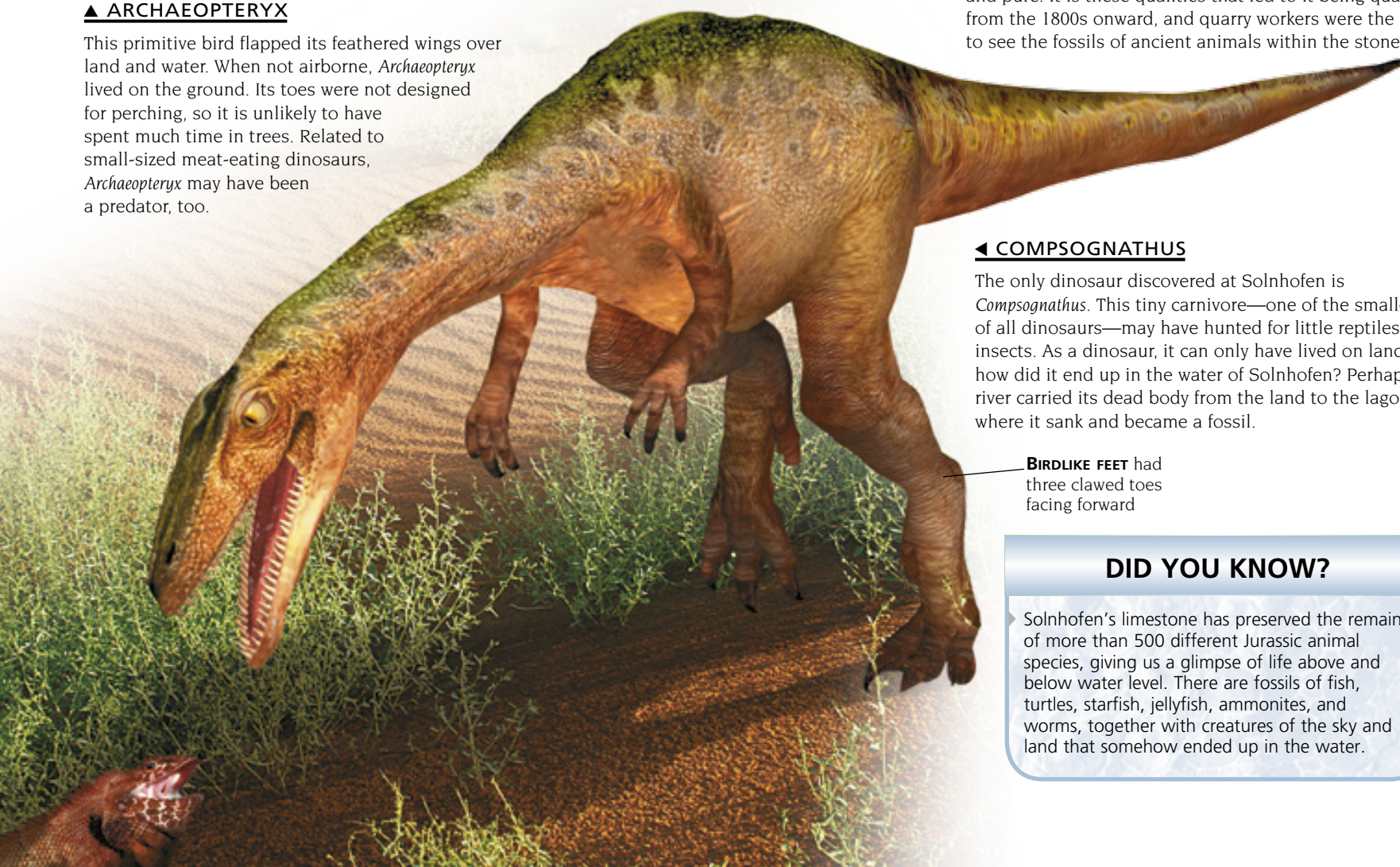
◀ COMPSOGNATHUS

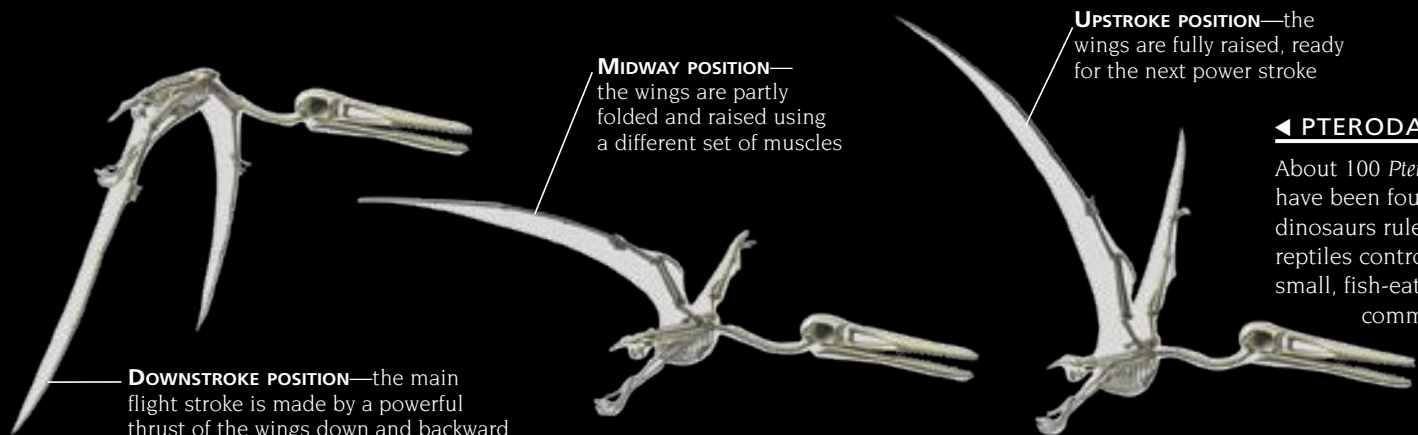
The only dinosaur discovered at Solnhofen is *Compsognathus*. This tiny carnivore—one of the smallest of all dinosaurs—may have hunted for little reptiles and insects. As a dinosaur, it can only have lived on land, so how did it end up in the water of Solnhofen? Perhaps a river carried its dead body from the land to the lagoon, where it sank and became a fossil.

BIRDLIKE FEET had three clawed toes facing forward

DID YOU KNOW?

▶ Solnhofen's limestone has preserved the remains of more than 500 different Jurassic animal species, giving us a glimpse of life above and below water level. There are fossils of fish, turtles, starfish, jellyfish, ammonites, and worms, together with creatures of the sky and land that somehow ended up in the water.





DOWNSTROKE POSITION—the main flight stroke is made by a powerful thrust of the wings down and backward

MIDWAY POSITION—the wings are partly folded and raised using a different set of muscles

UPSTROKE POSITION—the wings are fully raised, ready for the next power stroke

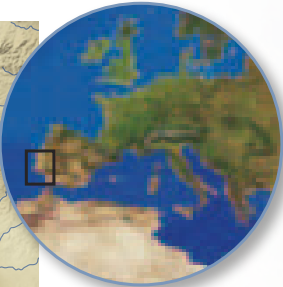
◀ **PTERODACTYLUS**

About 100 *Pterodactylus* specimens have been found at Solnhofen. While dinosaurs ruled the land, these flying reptiles controlled the skies, and the small, fish-eating *Pterodactylus* was a common sight. Its lightly built skeletal framework suggests that it was a powerful flyer.



Portugal

MORE THAN 20 SPECIES of dinosaur have been found in Portugal. They occur in rocks that range in age from about 150 to 95 million years ago—Middle Jurassic to Late Cretaceous. Herds of giant sauropods, *Camarasaurus* and *Brachiosaurus*, lived here in the Jurassic, moving slowly through leafy woodlands where conifers, ginkgoes, and tree palms grew in abundance. Smaller herbivores, such as *Camptosaurus*, were also here—as were fast-moving meat-eaters, who may have counted the plant-eaters among their prey. Portugal’s sauropod footprints and trackways are Europe’s best, revealing that these dinosaurs moved in groups.

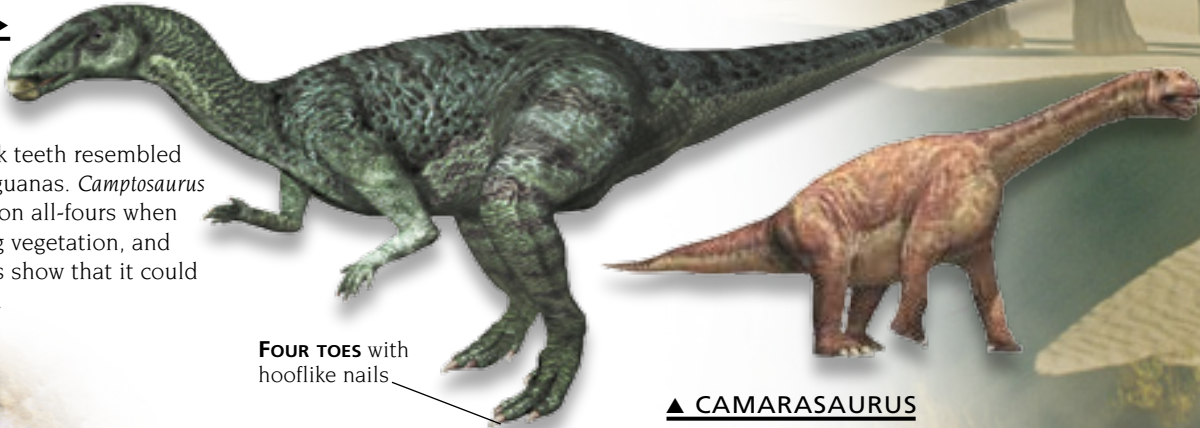


◀ SITE LOCATION

Portugal’s Jurassic dinosaur sites occur in regions close to the Atlantic coast, especially Beira Litoral and Estremadura.

CAMPTOSAURUS ▶

This dinosaur was an iguanodont, from a group of plant-eaters whose chisel-like cheek teeth resembled those of present-day iguanas. *Camptosaurus* seems to have walked on all-fours when grazing on low-growing vegetation, and its powerful hind limbs show that it could also move on two legs.



FOUR TOES with hooflike nails

◀ FOOTPRINTS

Dinosaur footprints have been found at more than 50 locations in Portugal. Some are isolated impressions, like this sauropod footprint, but others are long trackways that preserve part of the route a dinosaur took as it walked or ran over soft ground.



▲ CAMARASAURUS

A member of the sauropod group, *Camarasaurus* lived on a diet of soft plants, twigs, and branches. Its fossils occur in the Beira Litoral region of Portugal, where a Jurassic woodland was its home.



◀ BRACHIOSAURUS

The partial skeleton of a *Brachiosaurus*—one of the giants of the Jurassic—has been found in the Estremadura region of Portugal. This long-necked sauropod may have lived in herds. A plant-eater, it could reach up to graze on soft leaves and tough conifer needles at the very top of trees, which it swallowed without chewing.

BRACHIOSAURUS, at full stretch, could reach foliage 43 ft (13 m) above the ground

BACK LEGS were shorter than its front legs

DID YOU KNOW?

An adult *Brachiosaurus* weighed from 31 to 46 tons. It has been estimated that it needed to eat about 440 lbs (200 kg) of plants every day—that’s the combined weight of six average-sized 10-year-old children!

Spain

SPAIN HAS PRODUCED EVIDENCE for about 15 Jurassic and Cretaceous dinosaur species, from lightweight runners such as *Hypsilophodon* and *Pelecanimimus* to the heavyweight plodders that were the last of the sauropods. It is the members of this group that mark Spain out for special attention. Although the bones of these giants are rare, their eggs are not. At Bastús in northeast Spain, thousands of sauropod eggs have been found in nests. They were laid about 70 million years ago, on a sandy beach. No dinosaur fossils have been found at the site, but it is believed that the eggs belong to *Titanosaurus* or *Hypselosaurus*.



▲ SITE LOCATION

Spain’s major fossil sites are located in the north and east of the country. Las Hoyas is famous for its fossils of well-preserved Late Cretaceous plants and birds, and the Las Zabacheras Beds have produced evidence for dinosaurs.

▲ TITANOSAURUS

Titanosaurus was one of the last of the sauropods. It lived in the Late Cretaceous, and there is evidence for a colony in what is today northeast Spain, where a partial skeleton has been found. The skin on its back was covered in hard nodules, perhaps to protect it from predators.



◀ HYPSELOSAURUS

Incomplete *Hypselosaurus* skeletons have been found in the Spanish provinces of Soria and Lleida. Nearby, at Aix-en-Provence, France, 8 in- (20 cm-) long eggs are thought to belong to this plant-eating titanosaur. Like the rest of its group, it lived toward the end of the Cretaceous.



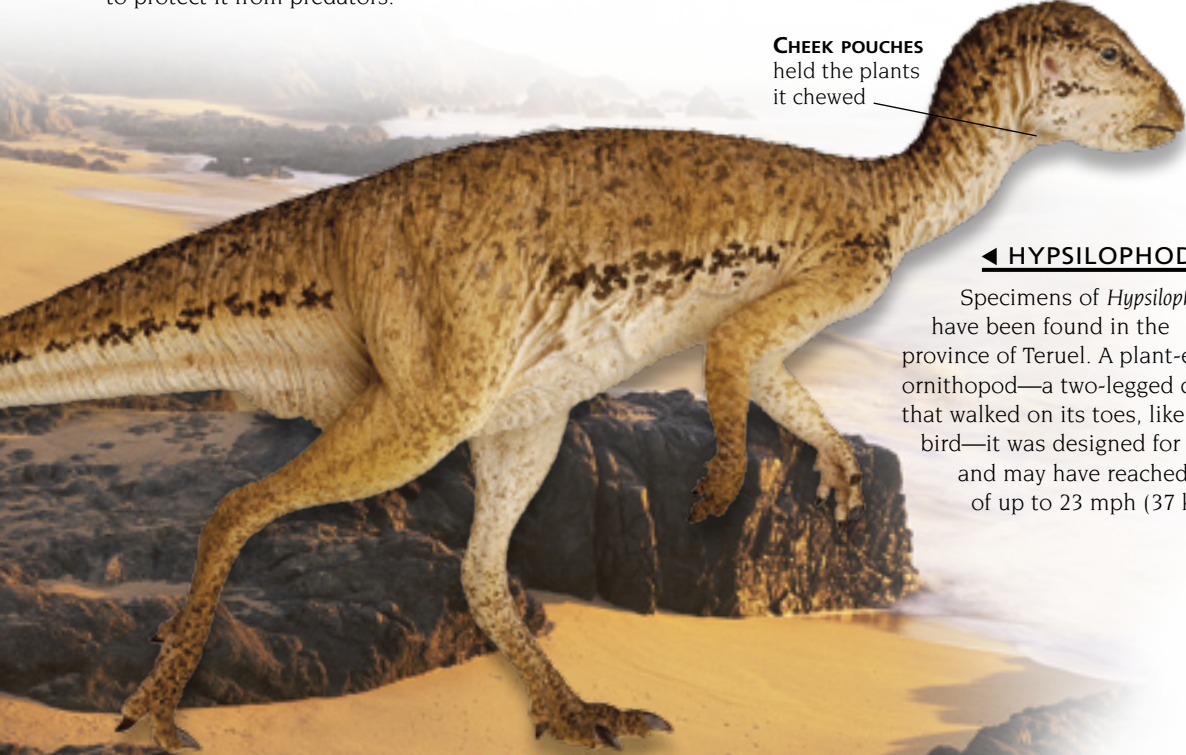
CUENCA TODAY ▶

The province of Cuenca is noted today for its rugged outcrops of Cretaceous limestone, which have been eroded by years of wind and water action. Within these rocks are dinosaur and other fossils.

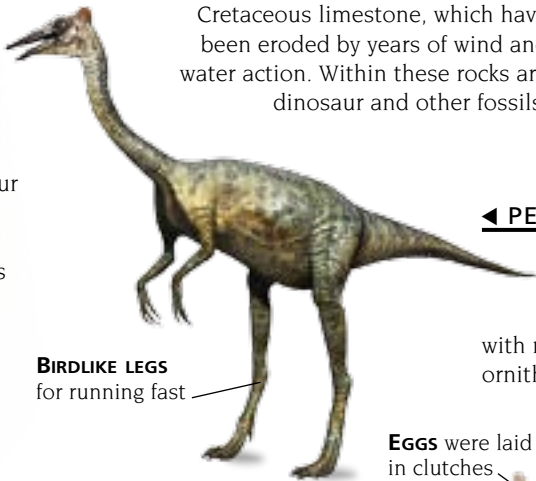


◀ HYPSILOPHODON

Specimens of *Hypsilophodon* have been found in the province of Teruel. A plant-eating ornithopod—a two-legged dinosaur that walked on its toes, like a bird—it was designed for speed, and may have reached bursts of up to 23 mph (37 kph).



CHEEK POUCHES held the plants it chewed



BIRDLIKE LEGS for running fast

◀ PELECANIMIMUS

Discovered near an ancient lake in the province of Cuenca, *Pelecanimimus* was a meat-eater with more than 200 tiny teeth. It was an ornithomimid or “bird mimic” dinosaur.

EGGS were laid in clutches

DINOSAUR EGGS ▶

Dinosaurs laid eggs. At Bastús there is a nest site with an estimated 300,000 melon-sized sauropods eggs.



Southern Britain

EARLY CRETACEOUS SOUTHERN BRITAIN was a vast floodplain that extended south from where London is today, across to France and Belgium. Rivers and streams flowed down from hills to the north, cutting their way through the plain, filling lakes, then slowing as they reached a massive delta clogged with sediment. The ancient foothills of London were clad with forests of conifers, monkey puzzle trees, and cycads, and the floodplain was a scene of open woodland and ferns. This was the home of *Baryonyx*, *Neovenator*, and *Iguanodon*—a plant-eater who was discovered before the word “dinosaur” was first used.



▲ SITE LOCATION

Dinosaur fossils found in southern Britain occur within deposits of Cretaceous sandstones, mudstones, clays, and gravels. This material was formed 145–125 million years ago, and is known as the Wealden Group.

BARYONYX ►

A predator of the Early Cretaceous, *Baryonyx* lived in marshy, open woodland. A nearly complete specimen was excavated in southeast England, and the remains of its last meal were found in its stomach area. It had eaten a *Lepidotes*—a large, bony fish.

Gideon Mantell



In his spare time, English doctor Gideon Mantell (1790–1852) collected and studied fossils from southern England. In February 1825, he announced his discovery of *Iguanodon*. This was only the second dinosaur to be named, at a time when interest in the bones of long-dead animals was just beginning to be taken seriously.



▲ DRAGONFLY

The watery landscape of Early Cretaceous Britain teemed with wildlife, of which dinosaurs were only a part. Lakes and rivers were the domain of fish, turtles, and crocodiles, and insects—especially dragonflies—were common. This dragonfly has been preserved right down to its wing veins and body stripes.

IGUANODON ►

A large herbivore, many *Iguanodon* specimens have been found across southern Britain. It lived in herds, grazing on horsetails and ferns, which it cropped with its bony, toothless beak. Cheek teeth then crushed its food to pulp before it was swallowed. Each thumb was equipped with a sharp spike, which *Iguanodon* may have used to stab at enemies.



◀ NEOVENATOR

Prowling the landscape of southern Britain was a top predator of the Early Cretaceous. This was *Neovenator*, a formidable carnivore, closely related to *Allosaurus* of North America. Its fossils have been found on the Isle of Wight, off the south coast of England, where it might have preyed upon *Iguanodon*.



SOME TEETH were 2 in (5 cm) long

CLAWS grew to 5 in (13 cm) long

HEAVY TAIL with two rows of spikes

SHOULDER SPIKES

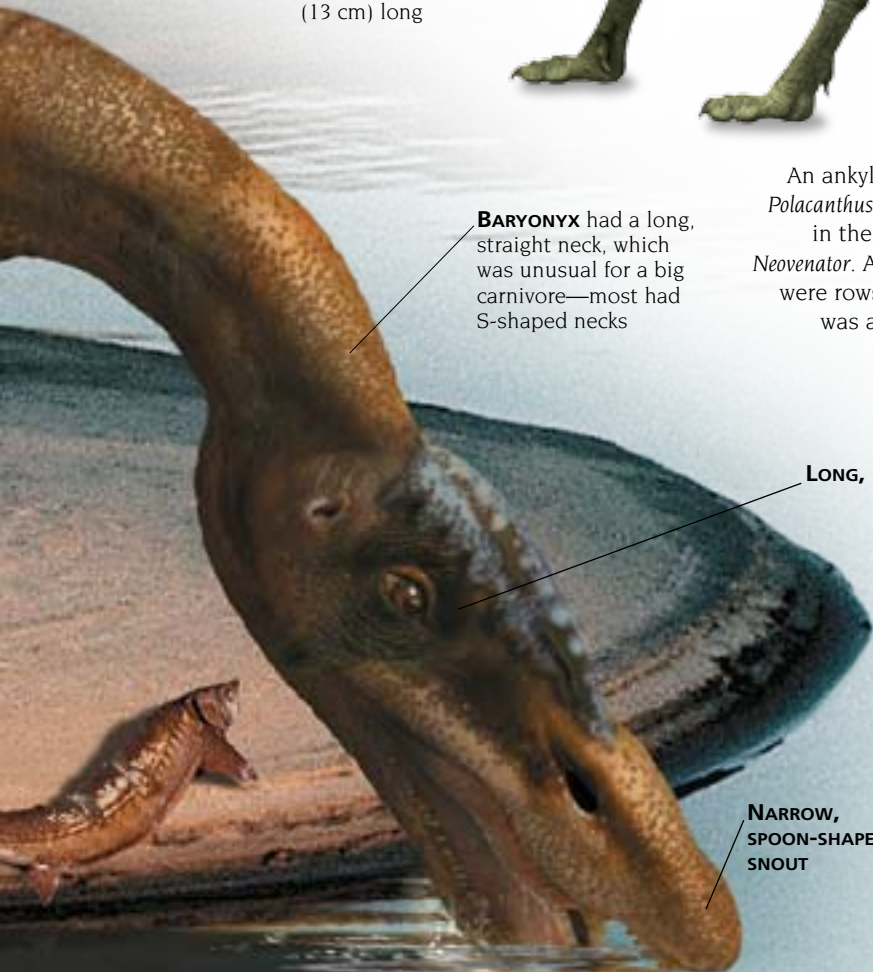
POLACANTHUS ►

An ankylosaur (armored dinosaur), *Polacanthus* lived at the same time and in the same area as *Iguanodon* and *Neovenator*. Along its neck, back, and tail were rows of spikes, and over its hips was a bony shield. These features protected *Polacanthus* during an attack.



LONG HEAD with a toothless beak

BARYONYX had a long, straight neck, which was unusual for a big carnivore—most had S-shaped necks



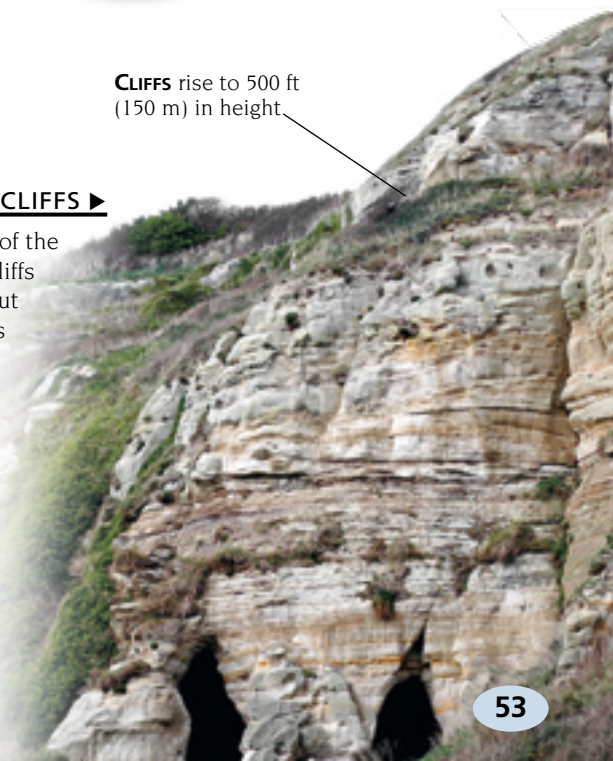
LONG, SLENDER HEAD

NARROW, SPOON-SHAPED SNOUT

CLIFFS rise to 500 ft (150 m) in height

HASTINGS CLIFFS ►

The Hastings Sands, part of the Wealden Group, seen in the cliffs at Hastings, formed about 140 million years ago. At this time, the region was part of an extensive river delta and floodplain. The cliffs are the result of sediment settling in rivers and lakes. Plant, fish, seashell, and dinosaur fossils are found here, including footprints of *Iguanodon*. Even Early Cretaceous sea ripples are preserved in amazing detail.



Hateg Island

IN THE LATE CRETACEOUS PERIOD, about 75 million years ago, the Hațeg Basin area of western Romania was an island in the Tethys Sea. Several dinosaur families lived on the island, including titanosaurs, hadrosaurs, ankylosaurs, and iguanodonts. This was a typical Late Cretaceous dinosaur mixture, which could also be found in other parts of the world. But what made the Hațeg Island animals interesting was their size—*Magyarosaurus*, *Rhabdodon*, and their contemporaries were smaller than usual. Over many generations, the species adapted to the limited food supplies on the island by shrinking in size.



▲ SITE LOCATION

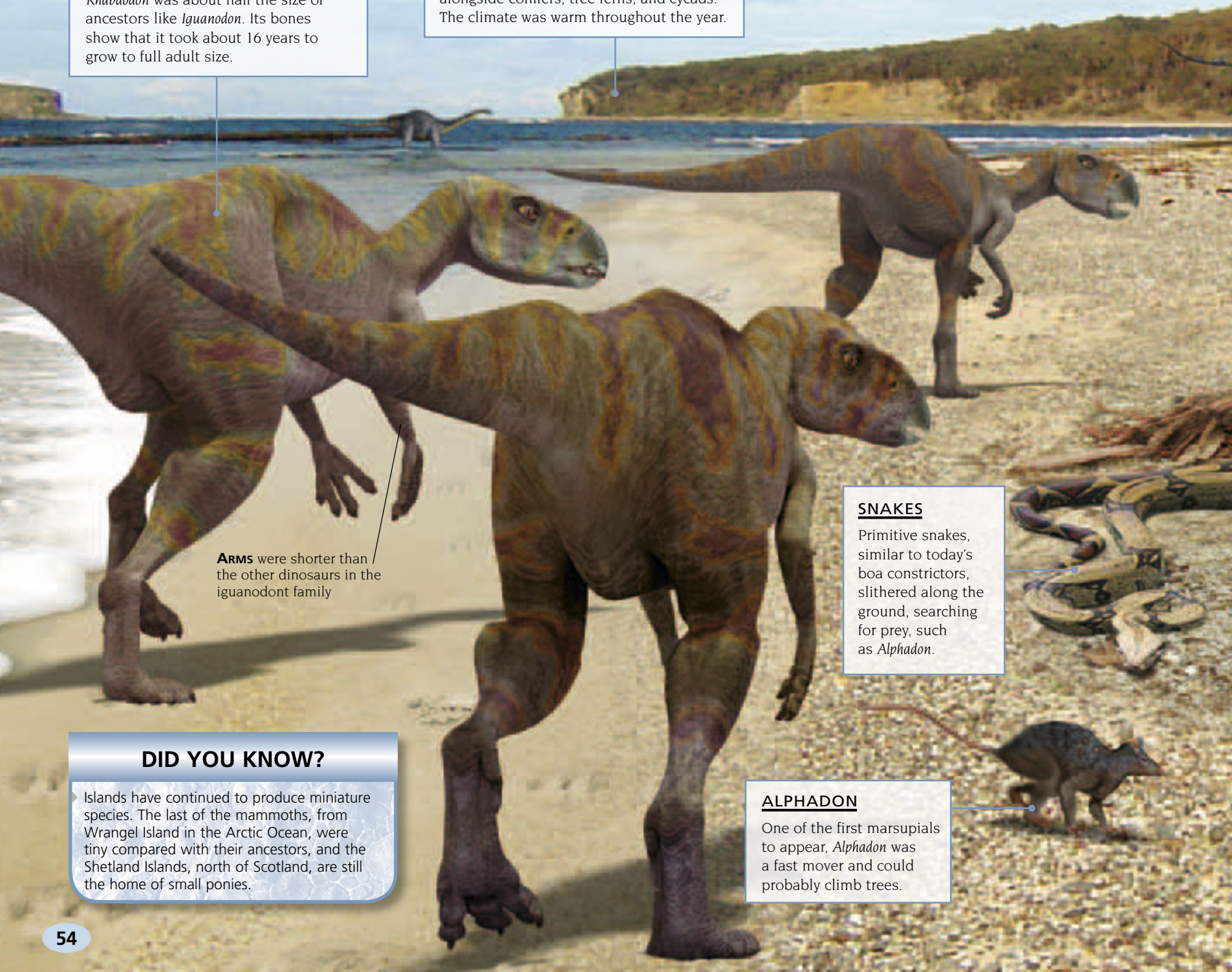
Hațeg is a town in western Romania. The name comes from the island that existed in the surrounding area during the Late Cretaceous. Many fossils have been unearthed around modern-day Hațeg.

RHABDODON

One of the last of the iguanodonts, *Rhabdodon* was about half the size of ancestors like *Iguanodon*. Its bones show that it took about 16 years to grow to full adult size.

HAȚEG LANDSCAPE

Oak, maple, walnut, and beech trees grew alongside conifers, tree ferns, and cycads. The climate was warm throughout the year.



ARMS were shorter than the other dinosaurs in the iguanodont family

SNAKES

Primitive snakes, similar to today's boa constrictors, slithered along the ground, searching for prey, such as *Alphadon*.



DID YOU KNOW?

Islands have continued to produce miniature species. The last of the mammoths, from Wrangel Island in the Arctic Ocean, were tiny compared with their ancestors, and the Shetland Islands, north of Scotland, are still the home of small ponies.

ALPHADON

One of the first marsupials to appear, *Alphadon* was a fast mover and could probably climb trees.





HATZEGOPTERYX

Above the island flew *Hatzegopteryx*, one of the largest of all pterosaurs. From tip to tip, its wings measured 46 ft (14 m).

MAGYAROSAURUS

A titanosaur, *Magyarosaurus* was one of the smallest and last of its family. Several incomplete fossil remains have been found in Romania.

TELMATOSAURUS

Several *Telmatosaurus* skulls have been found at Hațeg, together with clutches of eggs and hatchlings belonging to this hadrosaur.

STRUTHIOSAURUS

This plant eater was the smallest in the ankylosaur family of armored dinosaurs. It had bony studs on its neck and back while spikes guarded its sides.

KALLOKIBOTON

Turtles, like this *Kallokiboton*, swam in the surrounding ocean. They came ashore to lay their eggs, which were then buried in the soft sand.

CLUTCHES may have had between 50 and 200 eggs

HAȚEG TODAY

The ancient Tethys Sea and the island of miniature dinosaurs disappeared millions of years ago, leaving behind today's Hațeg Basin area—a low-lying depression crossed by rivers and ringed by mountains, some of which rise to heights of more than 8,200 ft (2,500 m). The sandstones and mudstones that formed here 75 million years ago contain the many fossils that tell the story of the area's ancient past.



Africa



AFRICA'S DINOSAURS ARE KNOWN from about 80 locations.

The continent's oldest dinosaurs date to the Late Triassic, about 200 million years ago, and are found in the south, particularly in South Africa, Lesotho, and Zimbabwe. The same region also accounts for Jurassic specimens, but it is the east African discoveries at Tendaguru, Tanzania, that really define Africa's dinosaurs of this period. The best examples of Cretaceous dinosaurs, from 70 million years ago, belong to Egypt, Morocco, and Algeria in north Africa, where giant carnivores and herbivores lived.

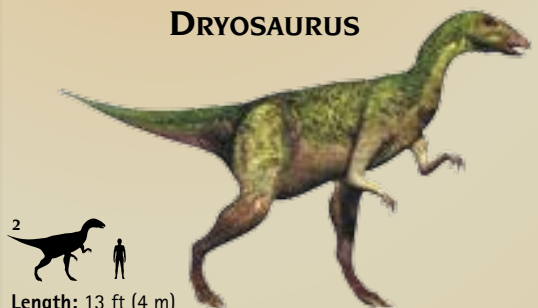
KEY	 JURASSIC PERIOD	 SITE
	 CRETACEOUS PERIOD	

BAROSAURUS



Length: 89 ft (27 m)
Pronunciation: ba-roh-sore-us
Meaning: "heavy lizard"

DRYOSAURUS



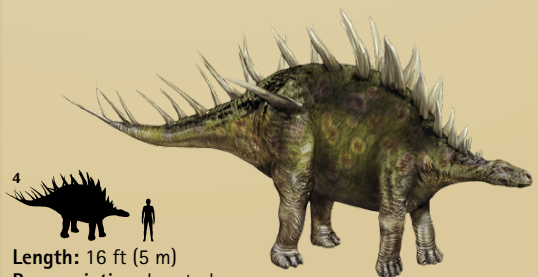
Length: 13 ft (4 m)
Pronunciation: dry-oh-sore-us
Meaning: "oak lizard"

HETERODONTOSAURUS



Length: 4 ft (1.2 m)
Pronunciation: het-er-oh-don-toh-sore-us
Meaning: "different-teeth lizard"

KENTROSAURUS



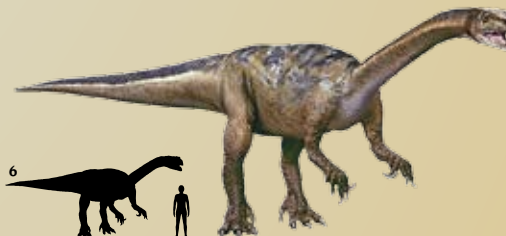
Length: 16 ft (5 m)
Pronunciation: ken-troh-sore-us
Meaning: "spiky lizard"

LESOTHO SAURUS



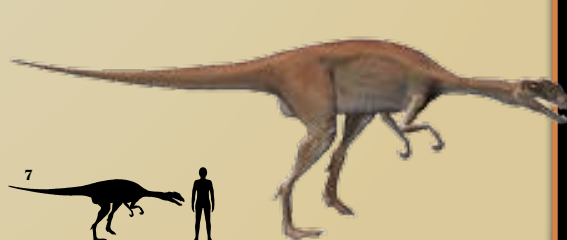
Length: 3 ft (1 m)
Pronunciation: le-so-toe-sore-us
Meaning: "Lesotho lizard"

MASSOSPONDYLUS



Length: 16 ft (5 m)
Pronunciation: mass-oh-spon-di-luss
Meaning: "massive vertebrae"

SYNTARSUS



Length: 10 ft (3 m)
Pronunciation: sin-tar-sus
Meaning: "fused tarsus"

VULCANODON



Length: 21 ft (6.5 m)
Pronunciation: vul-kan-oh-don
Meaning: "volcano tooth"

AEGYPTOSAURUS



Length: 49 ft (15 m)
Pronunciation: ee-jip-toe-sore-us
Meaning: "Egyptian lizard"

CARCHARODONTOSAURUS



Length: 49 ft (15 m)
Pronunciation: kar-kar-o-don-toe-sore-us
Meaning: "Carcharodon lizard"

PARALITITAN



Length: 89 ft (27 m)
Pronunciation: pa-ral-ih-tie-tan
Meaning: "tidal giant"

SPINOSAURUS



Length: 49 ft (15 m)
Pronunciation: spy-noh-sore-us
Meaning: "thorn lizard"



BAHARIYA OASIS

Cretaceous fossils were found here in the early 1900s, but were destroyed during World War II. Only now are paleontologists studying the area again, and new discoveries are being made.

THE MAP

Some of Africa's major dinosaur locations are shown on this map, together with the dinosaurs found there.

LIBYA

ALGERIA

MAURITANIA

MALI

NIGER

BURKINA

GUINEA

IVORY
COAST

GHANA
TOGO
BENIN

NIGERIA

CHAD

CAMEROON

CENTRAL AFRICAN
REPUBLIC

GABON

CONGO

DEMOCRATIC
REPUBLIC OF
CONGO

UGANDA

SUDAN

ETHIOPIA

SAUDI
ARABIA

ANGOLA

TANZANIA

ZAMBIA

NAMIBIA

BOTSWANA

ZIMBABWE

MOZAMBIQUE

SOUTH AFRICA

SWAZILAND

LESOTHO

MADAGASCAR

TENDAGURU

One of the world's greatest dinosaur bone beds was excavated here, uncovering Jurassic sauropods, stegosaurs, and carnivores, together with sharks, crocodiles, fish, and pterosaurs.



MADAGASCAR

About 150 million years ago, Madagascar broke away from Africa, leaving its dinosaurs to develop on their own. However, since it was joined to India, there are similarities with the dinosaurs that have been found in India.

Southern Africa



▲ SITE LOCATION

Dinosaurs of southern Africa have been found in several countries, including South Africa, Zimbabwe, and Namibia.

AFRICA'S MOST ANCIENT DINOSAURS are found in the south of the continent. Here, in the Early Jurassic, about 200 million years ago, herds of tiny *Lesothosaurus* lived alongside the first of the giant plant-eaters, such as *Massospondylus* and *Vulcanodon*. This warm and dry region was also home to small lizards and early mammals, and hunting them was the carnivore *Syntarsus*—a fierce predator of this semidesert environment.

FLYING CREATURES would have been eaten by *Syntarsus*, and it might also have attacked the area's large herbivores

DID YOU KNOW?

► *Syntarsus* was named in 1969, but in 2001 it was found that the name was already in use—for a beetle. So a new name was proposed (*Megapnosaurus*). But paleontologists didn't like the name, and both names are now used for it.

MEGAZOSTRODON

An early mammal, the shrewlike *Megazostrodon* hunted at night for insects. If it came out in the day, it was in danger of being eaten itself.

SYNTARSUS

This dinosaur was one of the first Jurassic carnivores. A fast-moving hunter, it had sharp, biting teeth, and long fingers to grip prey.

SOUTHERN AFRICA TODAY

The Southern Plateau dominates the region. This is a vast area of flat, high ground, 3,000–5,000 ft (900–1,500 m) above sea level, which gradually falls away to a lowland coastal zone. There are a variety of climates, from tropical wet and dry, to arid or semiarid, and even desert.



VEGETATION

The region's plants were dominated by palmlike cycads as tall as trees. Ferns and horsetails were on the ground.

VULCANODON

A plant-eater, *Vulcanodon* swallowed its food whole. Small stones in its stomach would have helped digest the tough plant material.

BACKWARD-POINTING TEETH of *Syntarsus* made it impossible for prey, such as this *Megazostrodon*, to wriggle free

MASSOSPONDYLUS

This dinosaur may have used its hands for holding food and for walking.

LESOTHO SAURUS

In hot weather, *Lesothosaurus* may have kept cool by going underground. The evidence comes from fossils found in a burrow.

HETERODONTOSAURUS

The agile *Heterodontosaurus* had three different types of teeth for biting, grinding, and tearing food.

DIPHYDONTOSAURUS

The area's meat-eaters probably hunted this small lizardlike reptile. It would have used speed to escape from them.

Tendaguru

A GEM HUNTER SEARCHING IN EAST AFRICA made one of the most remarkable dinosaur discoveries ever. It was 1907, and instead of finding small garnet stones for use in jewelry, the German collector stumbled across giant, fossilized bones at Tendaguru. Between 1909 and 1913, German paleontologists and hundreds of local workers recovered 250 tons of fossils, all of which were carried to Lindi, from where they were shipped to Germany. From the mass of bones, 150 million years old, emerged dinosaurs of the Late Jurassic—sauropods such as *Barosaurus* and *Brachiosaurus*, the stegosaur *Kentrosaurus*, and about 10 other species.



▲ SITE LOCATION

Tendaguru is in southeast Tanzania, about 46 miles (75 km) from the port of Lindi. When the site was excavated, it could only be reached on foot, after a four-day march.

SMALL HEAD with large, forward-facing eyes

◀ DRYOSAURUS

This dinosaur was a medium-sized member of the hypsilophodont family—a group of fast-moving dinosaurs with distinctive self-sharpening chewing teeth. *Dryosaurus* was probably a herd-dweller, grazing on low-growing ferns and other plants that grew on dry land close to the area's rivers.

THREE TOES on each foot

FIVE FINGERS on each hand

POWERFUL TAIL counterbalanced the long neck

▶ BAROSAURUS

Several partial *Barosaurus* skeletons have been found at Tendaguru. Its front legs were shorter than its hind legs, which would have reduced the weight at the front of its body. This may have allowed it to stand up on its back legs.

Werner Janensch



German paleontologist Werner Janensch (1878–1969) led the Tendaguru expedition between 1909 and 1913. In this remote part of Tanzania, he discovered the complete skeleton of *Brachiosaurus* as well as other sauropod bones.

▲ TENDAGURU THEN AND NOW

In the Late Jurassic, Tendaguru was a lagoon or estuary. Rivers flowed into it, carrying the corpses of animals to a mass grave. Sediments fossilized them, and it is these deposits of red sandstone that have yielded Africa's finest examples of dinosaurs.

ELONGATED, HEAVY NECK
made up one-third of
Brachiosaurus's length

PROTECTIVE PLATES
of bone in pairs
along the neck
and upper back

**FOURTEEN
BONY PLATES**
on its back

**HOOFLIKE
CLAWS** on toes

HIND LEGS were
twice as long as
the front legs

▲ KENTROSAURUS SKELETON

The skeleton of *Kentrosaurus* reveals its framework. It had two rows of bony plates on each side of its backbone, protecting its neck, shoulders, and the front part of its back. From its lower back and tail grew seven pairs of sharp spines.

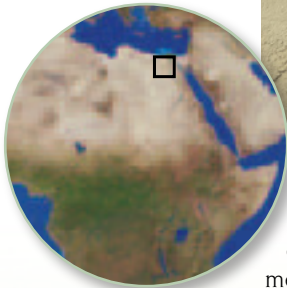
EACH SPINE
was up to 2 ft
(60 cm) long.

◀ KENTROSAURUS

A stegosaur—the family of plant-eating dinosaurs whose bodies were protected by spines and plates of bone—*Kentrosaurus* had a small head with a brain that was no bigger than a walnut.

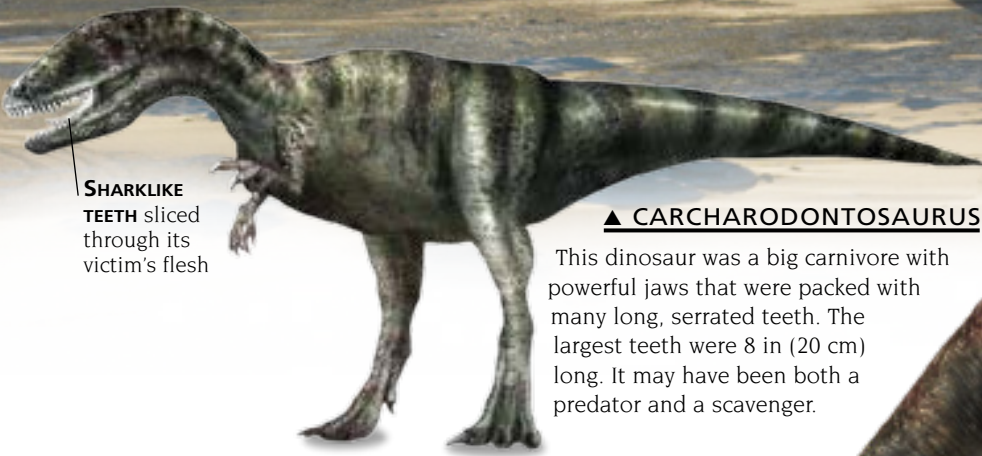
Bahariya Oasis

EGYPT'S MODERN LANDSCAPE is a sandy desert through which flows the Nile River. It hasn't always been like this. In the Late Cretaceous, this part of North Africa was a coastal zone bordering the ancient Tethys Sea. Around 95 million years ago the area was a swampland of shallow tidal marshes, water channels, and tropical forest. This was a good place for turtles, crocodiles, and dinosaurs to live. *Spinosaurus*—a predator on a scale with *Tyrannosaurus rex*—caught fish here, and there were enough plants to feed *Paralititan*, a truly massive sauropod. The area where these and other dinosaurs have been found is today's Bahariya Oasis, an island of trees and farms surrounded by Egypt's Western Desert.



▲ SITE LOCATION

Bahariya Oasis is 180 miles (290 km) southwest of Cairo. A shallow depression in the desert floor, it measures 58 miles long by 26 miles wide (94 km by 42 km).



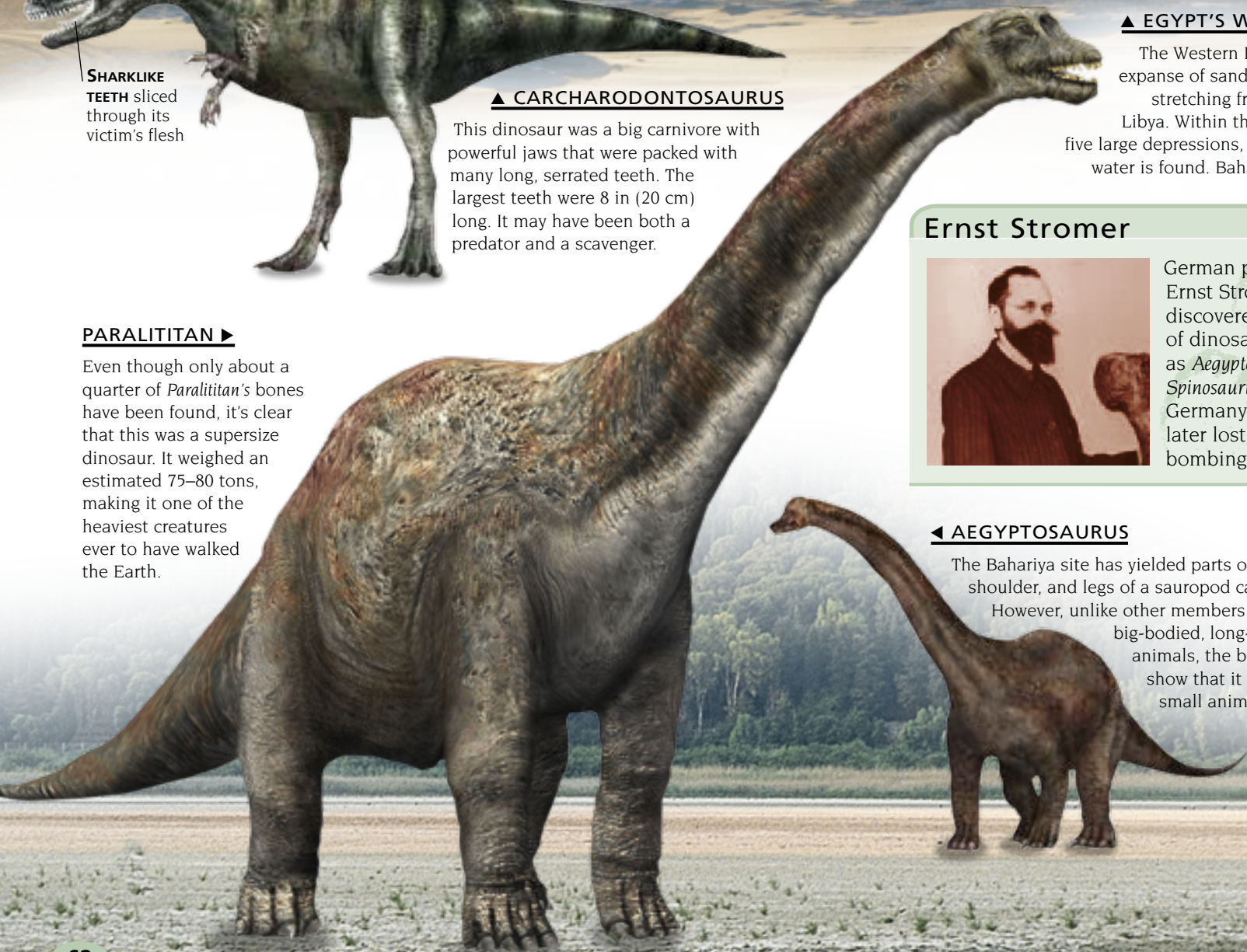
SHARKLIKE TEETH sliced through its victim's flesh

▲ CARCHARODONTOSAURUS

This dinosaur was a big carnivore with powerful jaws that were packed with many long, serrated teeth. The largest teeth were 8 in (20 cm) long. It may have been both a predator and a scavenger.

PARALITITAN ►

Even though only about a quarter of *Paralititan*'s bones have been found, it's clear that this was a supersize dinosaur. It weighed an estimated 75–80 tons, making it one of the heaviest creatures ever to have walked the Earth.



▲ EGYPT'S WESTERN DESERT

The Western Desert of Egypt is an expanse of sand and chalk outcrops, stretching from the Nile River to Libya. Within the hot, dry desert are five large depressions, each an oasis where water is found. Bahariya is one of them.

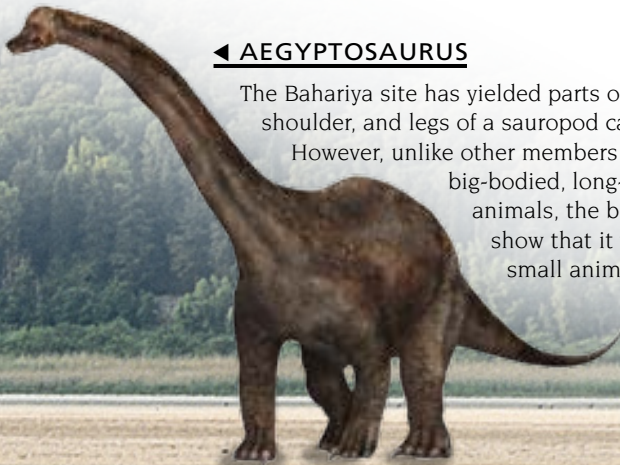
Ernst Stromer

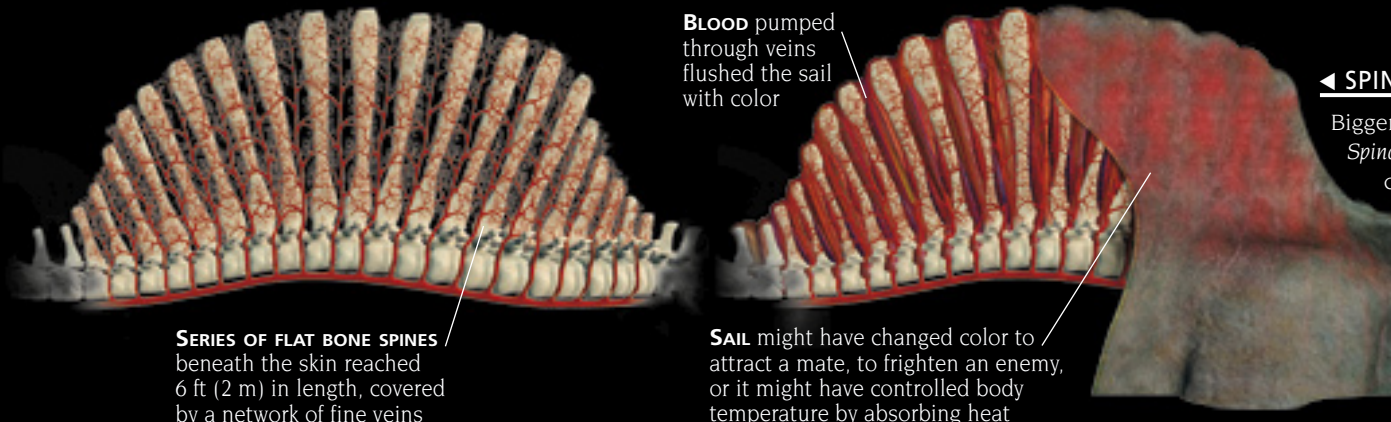


German palaeontologist Ernst Stromer (1870–1952) discovered the fossils of dinosaurs such as *Aegyptosaurus* and *Spinosaurus*. Taken to Germany, the fossils were later lost in a World War II bombing raid.

◀ AEGYPTOSAURUS

The Bahariya site has yielded parts of the backbone, shoulder, and legs of a sauropod called *Aegyptosaurus*. However, unlike other members of this group of big-bodied, long-necked, heavyweight animals, the bones of *Aegyptosaurus* show that it was a relatively small animal.





BLOOD pumped through veins flushed the sail with color

This diagram shows a cross-section of the Spinosaurus sail. It illustrates a series of flat bone spines on the left, which are covered by a network of fine veins. On the right, the sail is shown as a large, reddish structure with a network of veins running through it. A line points from the text 'BLOOD pumped through veins flushed the sail with color' to the vein network in the sail.

SERIES OF FLAT BONE SPINES beneath the skin reached 6 ft (2 m) in length, covered by a network of fine veins

SAIL might have changed color to attract a mate, to frighten an enemy, or it might have controlled body temperature by absorbing heat

◀ SPINOSAURUS

Bigger even than *Tyrannosaurus rex*, *Spinosaurus* was a formidable carnivore and was probably the top predator in its area. Its long jaws seem to have been designed for catching fish—but it is the curious skin “sail” along the length of its back that is its most striking feature, though its purpose is uncertain.





KEY	TRIASSIC PERIOD	SITE
	JURASSIC PERIOD	PROVINCE
	CRETACEOUS PERIOD	

CHINA

China has produced the world's best examples of Early Jurassic dinosaurs. However, it is the ones from the Late Cretaceous that have increased our knowledge the most, as fossils such as this *Sinosauropteryx* are preserved in magnificent detail.



THE MAP

Some of Asia's major fossil locations are shown on this map, together with some of the prehistoric animals found there.

ALWALKERIA



Length: unknown
Pronunciation: al-wah-keer-ee-a
Meaning: "Alick Walker's" (after Alick Walker, a British paleontologist)

GASOSAURUS



Length: 13 ft (4 m)
Pronunciation: gas-oh-sore-us
Meaning: "gas lizard"

HUAYANGOSAURUS



Length: 13 ft (4 m)
Pronunciation: hoy-yang-oh-sore-us
Meaning: "Huayang lizard"

Asia



THE CONTINENT OF ASIA is changing the way we think about dinosaurs. About 275 locations have produced fossil evidence, from the Late Triassic through to the end of the Cretaceous. While Triassic specimens are scarce, known only from India and Thailand, evidence for Jurassic and Cretaceous dinosaurs is plentiful. Discoveries from China—of small feathered carnivores such as *Caudipteryx*—have shown that dinosaurs and birds are related.

LUFENGOSAURUS



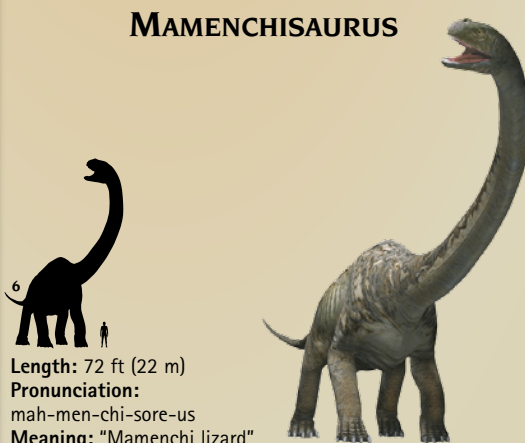
Length: 20 ft (6 m)
Pronunciation: loo-fung-oh-sore-us
Meaning: "Lufeng lizard"

LUKOSAURUS



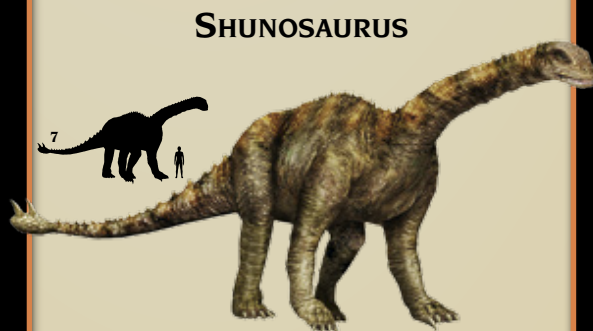
Length: 6½ ft (2 m)
Pronunciation: lew-koo-sore-us
Meaning: "Lukou lizard"

MAMENCHISAURUS



Length: 72 ft (22 m)
Pronunciation: mah-men-chi-sore-us
Meaning: "Mamenchi lizard"

SHUNOSAURUS



Length: 33 ft (10 m)
Pronunciation: shoo-noh-sore-us
Meaning: "Shuno lizard"

CAUDIPTERYX



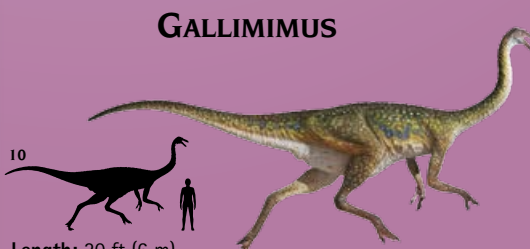
Length: 3 ft (1 m)
Pronunciation: caw-dip-ter-iks
Meaning: "tail feather"

CONFUCIUSORNIS



Length: 10 in (25 cm)
Pronunciation: kon-few-shus-or-niss
Meaning: "Confucius bird"

GALLIMIMUS



Length: 20 ft (6 m)
Pronunciation: gal-lee-meem-us
Meaning: "chicken mimic"

LIAOXIORNIS



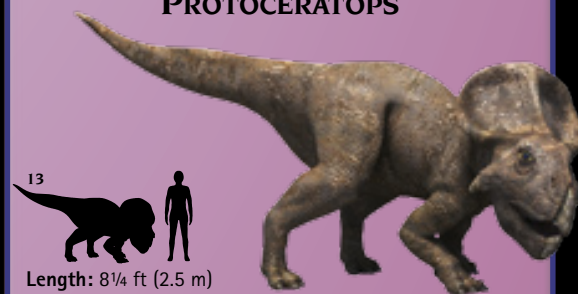
Length: 3¼ in (8.5 cm)
Pronunciation: lie-ox-ee-or-niss
Meaning: "Liaoxi bird"

OVIRAPTOR



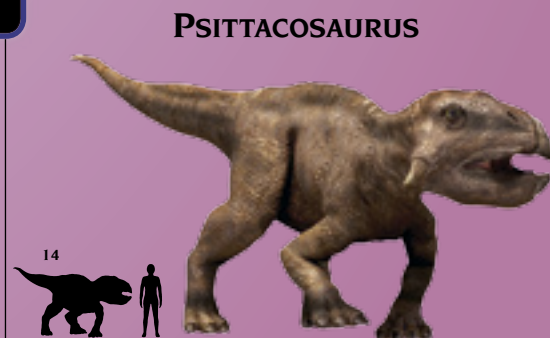
Length: 6½ ft (2 m)
Pronunciation: oh-vee-rap-tor
Meaning: "egg thief"

PROTOCERATOPS



Length: 8¼ ft (2.5 m)
Pronunciation: pro-toe-ker-ah-tops
Meaning: "first-horned face"

PSITTACOSAURUS



Length: 8¼ ft (2.5 m)
Pronunciation: sit-ak-oh-sore-us
Meaning: "parrot lizard"

SINORNITHOSAURUS



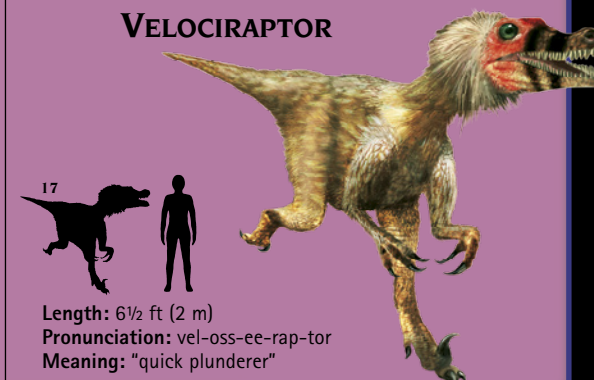
Length: 3 ft (1 m)
Pronunciation: si-norn-ith-oh-sore-us
Meaning: "Chinese bird lizard"

SINOSAUROPTERYX



Length: 3 ft (1 m)
Pronunciation: si-noh-sore-op-ter-iks
Meaning: "Chinese lizard wing"

VELOCIRAPTOR



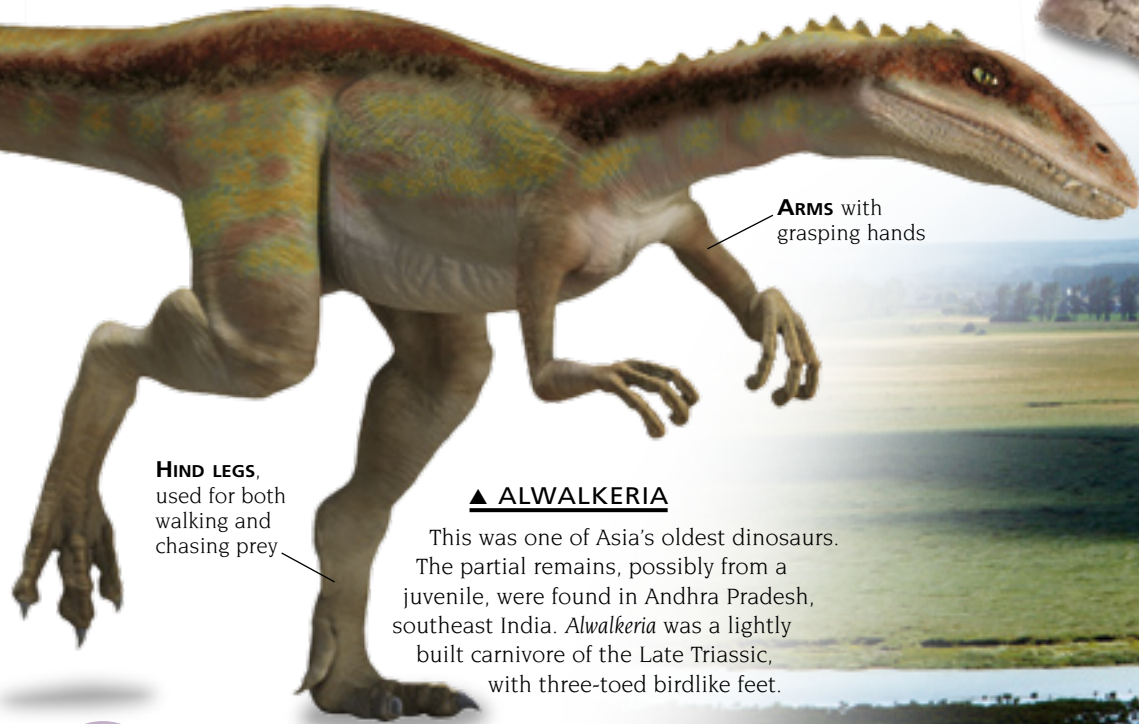
Length: 6½ ft (2 m)
Pronunciation: vel-oss-ee-rap-tor
Meaning: "quick plunderer"

India

THE STORY OF INDIA’S DINOSAURS begins in the Late Triassic, about 220 million years ago, when they were just beginning to make their presence felt across the ancient world. At this remote time, India was locked to the southern part of Pangaea, the supercontinent made up of all Earth’s land. It was attached to what would become Africa and Antarctica, after the break up of Pangaea. In an area of floodplains and rivers, where today’s Pranhita-Godavari river basin lies, crocodilelike reptiles snapped up fish, but the likes of *Parasuchus* were not destined to inherit the world. That honor went to the dinosaurs, and India’s *Alwalkeria* was one of the first of its kind, paving the way for the larger carnivores of the Jurassic and Cretaceous.

PARASUCHUS ▼

It looked like a crocodile, walked like a crocodile, had jaws like a crocodile, and lived like a crocodile. Despite these similarities, *Parasuchus* was not a crocodile at all. It was a phytosaur—a semiaquatic, meat-eating reptile that thrived in the Triassic, but became extinct at the end of this period.



ARMS with grasping hands

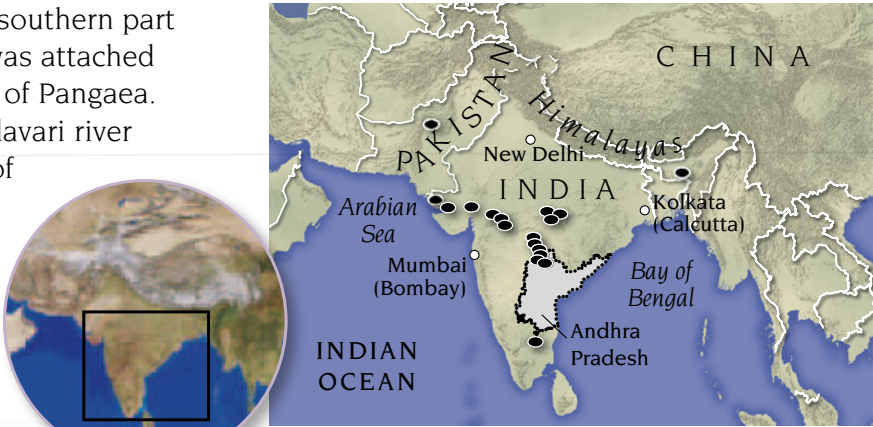
HIND LEGS, used for both walking and chasing prey

▲ ALWALKERIA

This was one of Asia’s oldest dinosaurs. The partial remains, possibly from a juvenile, were found in Andhra Pradesh, southeast India. *Alwalkeria* was a lightly built carnivore of the Late Triassic, with three-toed birdlike feet.

▲ THE LANDSCAPE TODAY

India’s Pranhita and Godavari rivers flow south to the Bay of Bengal, following channels through a river basin, which is a depression in the Earth’s crust. This is a vast area of low-lying ground, prone to flooding during the monsoon season.



▲ SITE LOCATION

India’s dinosaurs date from the Late Triassic to the Late Cretaceous. Their bones, trace fossils, and trackways are found in a number of locations throughout the country, as shown above.

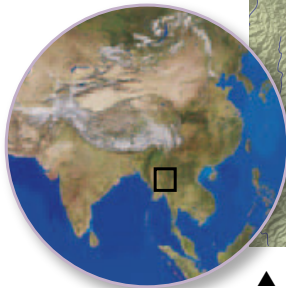
◀ LUNGFISH

Ceratodus fossils are found in the area’s Late Triassic rocks. As this lungfish lived in rivers and lakes, it provides good evidence for the area’s watery environment of 220 million years ago.



Lufeng Basin

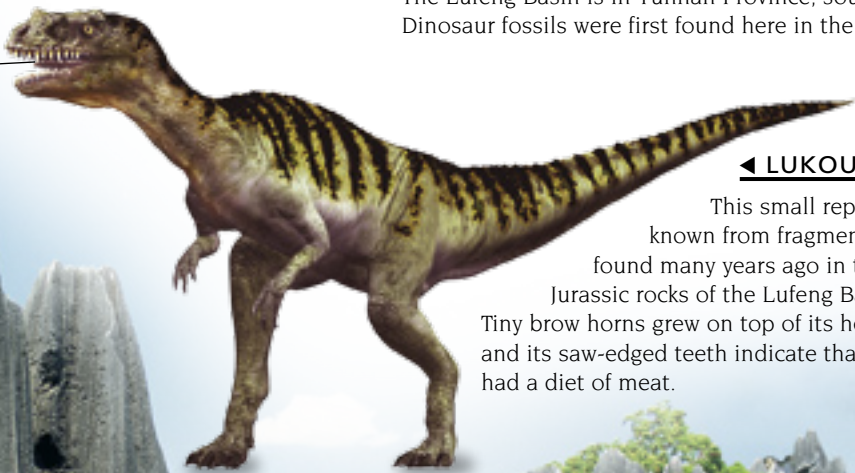
IN THE EARLY JURASSIC, about 200 million years ago, a shallow inland sea covered much of southern China. Rivers flowed into it, and on their floodplains lived prosauropods, a group of large plant-eaters that came before the sauropods. It was the discovery of one of these, *Lufengosaurus*, that alerted the world's paleontologists to the importance of the Lufeng Basin rocks, where red-colored sandstones, mudstones, and shales had built up to a depth of 3,280 ft (1,000 m). About 12 Early Jurassic dinosaur species have been found here, which has led to the region becoming known as China's "dinosaur homeland."



▲ SITE LOCATION

The Lufeng Basin is in Yunnan Province, southwest China. Dinosaur fossils were first found here in the late 1930s.

TEETH were serrated and backward curving



◀ LUKOUSAUROS

This small reptile is only known from fragments of skull, found many years ago in the Early Jurassic rocks of the Lufeng Basin. Tiny brow horns grew on top of its head, and its saw-edged teeth indicate that it had a diet of meat.

DID YOU KNOW?

Some paleontologists believe *Lukousaurus* was not a dinosaur at all. They say its skull is more like that of an early crocodile.

◀ LUFENGOSAURUS SKELETON

Several *Lufengosaurus* skeletons have been recovered, enabling it to be rebuilt with accuracy—in fact, it was China's first mounted dinosaur. This specimen has been mounted in a standing pose, as if stretching up to reach leaves 10–13 ft (3–4 m) above the ground.

LARGE CLAWS on each thumb

STRONG HIND LEGS supported it standing up

LONG, MOBILE NECK

SHORT FRONT LEGS

BIG TAIL to counterbalance its body

◀ LUFENGOSAURUS

This dinosaur was a prosauropod. It had small, flat teeth with serrated edges, which were well designed for shredding vegetation. It's thought *Lufengosaurus* walked on all fours, and could stand on its hind legs to reach plants growing high up.

Dashanpu

IN THE MIDDLE JURASSIC, 165 million years ago, central China was a lowland river plain. The region was prone to flooding, and many dinosaurs drowned in the rising waters. Their bodies were washed downriver, where they collected at river bends before slowly sinking in tangled groups into muddy sediments. Over time, the rivers disappeared, leaving deposits behind that set into the sandstones and mudstones of Sichuan Province. In 1972, at Dashanpu, an enormous bone bed of dinosaur fossils was discovered. More than 8,000 bones have been excavated, revealing sauropods such as the incredibly long-necked *Mamenchisaurus*, the small ankylosaur *Huayangosaurus*, and the carnivore *Gasosaurus*.

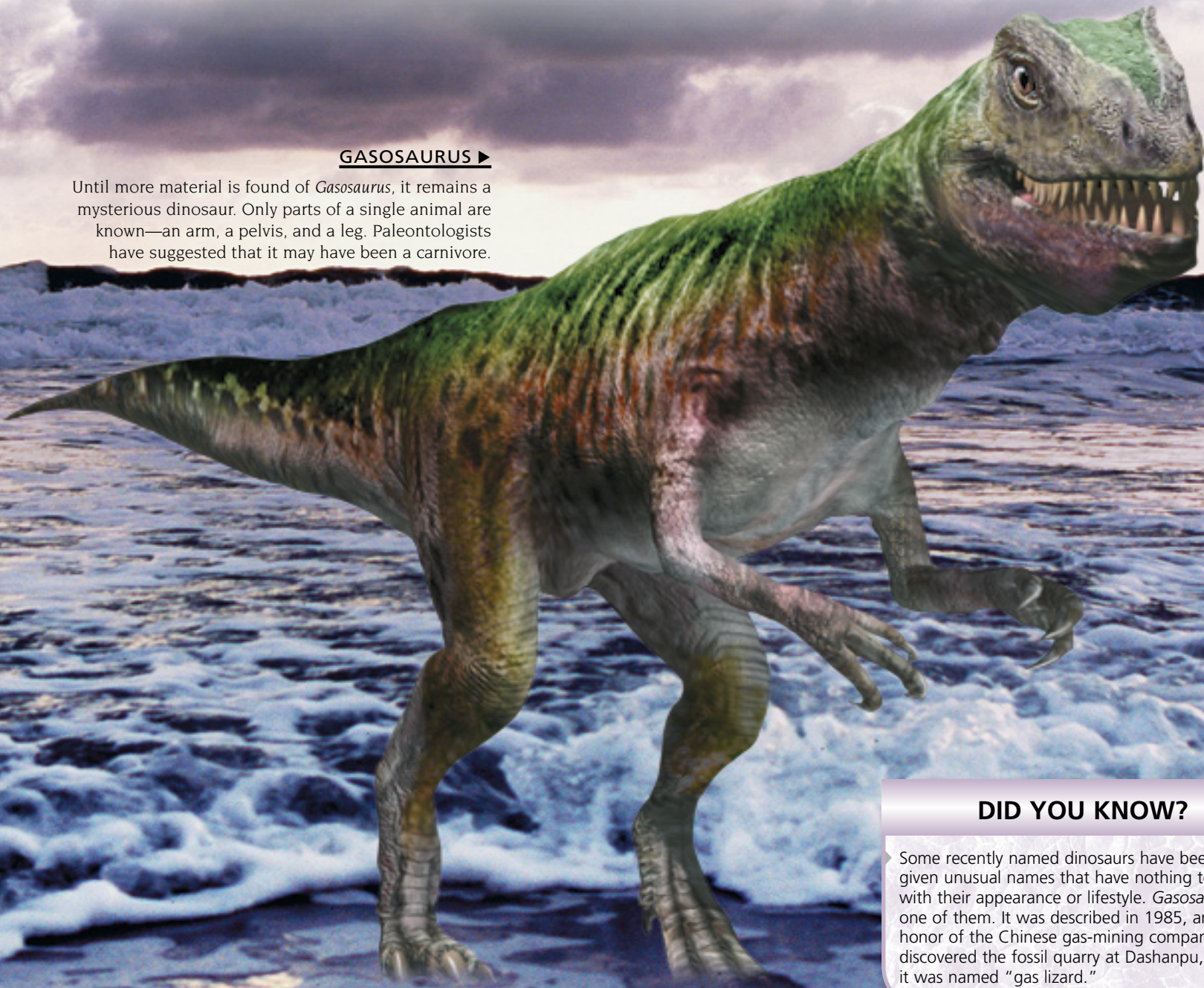


▲ SITE LOCATION

The Dashanpu Dinosaur Quarry is in central Sichuan Province, southwest China. Part of the site now houses the Zigong Dinosaur Museum, which displays China’s best collection of dinosaur fossils.

GASOSAURUS ►

Until more material is found of *Gasosaurus*, it remains a mysterious dinosaur. Only parts of a single animal are known—an arm, a pelvis, and a leg. Paleontologists have suggested that it may have been a carnivore.



DID YOU KNOW?

Some recently named dinosaurs have been given unusual names that have nothing to do with their appearance or lifestyle. *Gasosaurus* is one of them. It was described in 1985, and in honor of the Chinese gas-mining company that discovered the fossil quarry at Dashanpu, it was named “gas lizard.”



▲ SHUNOSAURUS SKELETON

In this exhibit, a *Shunosaurus* skeleton has been mounted as if it is reaching up to strip leaves from trees. It had a precision bite, and as its jaws closed its teeth rubbed against each other.

NECK was long and flexible

FORELEGS were relatively short

◀ SHUNOSAURUS

This slow-moving plant-eater had a bulky body with a long neck and tail. Unlike other sauropods, *Shunosaurus* was armed with a bony tail club that had two spikes. This would have been an effective weapon against a predator.

BONY CLUB for self-defense

SICHUAN TODAY ▲

The eastern part of Sichuan Province is fringed by mountains and has a warm, humid climate. The western part is a misty and cool highland zone. The Yangtze River, China's longest waterway, flows through Sichuan.

TAIL SPIKES were for self-defense

SMALL ARMOR PLATES along each flank

▲ HUAYANGOSAURUS

This early stegosaur had thick bony plates running down the length of its back, and spikes grew at the end of its tail. It had front teeth, and its long forelegs were also unusual—later stegosaurs had short front limbs and longer back legs.

NECK was about 50 ft (15 m) long in an adult, and would not have been held much higher than the shoulder

◀ MAMENCHISAURUS

A plant-eater, *Mamenchisaurus* had the longest neck of any dinosaur. Despite its size, the neck was lightweight because it was built from hollow vertebrae which, in places, were eggshell thin. These were important weight-saving features. The 19 bones that made up this sauropod's neck were linked by bony struts, making it stiff and not very flexible.

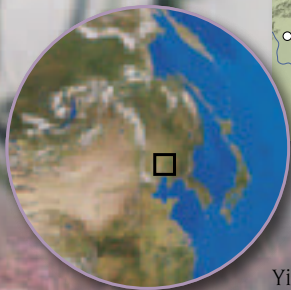
Liaoning

FOSSILS CHIPPED FROM THE EARLY CRETACEOUS rocks of China's Liaoning Province have revolutionized the study of dinosaurs. In this area, 125 million years ago, small meat-eating dinosaurs and primitive birds lived together in a forested landscape dotted with freshwater lakes. Animals that died and fell into the water were buried by ash from nearby volcanoes. In 1996, the discovery of *Sinosauropteryx* changed the way people thought about dinosaurs—the *Sinosauropteryx* fossil had a featherlike coat, strengthening claims that dinosaurs and birds are related.



▲ SITE LOCATION

Liaoning Province is in northeast China, and the dinosaur-bearing siltstones of the Yixian Formation are in the west.



LONG TAIL FEATHERS—it is thought that these were present on male birds only

CLAWED FINGERS on each wing

CONFUCIUSORNIS

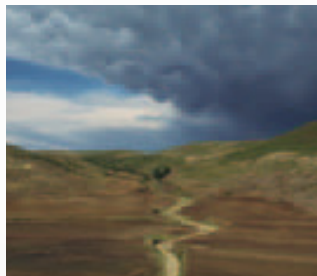
Like today's birds, *Confuciusornis* had a toothless beak, perched in trees, and ate plants. However, it was related to dinosaurs—its wing fingers were similar to the grasping hands of theropod dinosaurs.

PSITTACOSAURUS

This plant-eating dinosaur had a square skull and curved beak—hence its name, “parrot lizard.” Jutting out from the side of its face were cheekbones that formed horns, which may have been used for fighting.

LIAONING TODAY

One-third of Liaoning Province is forested, most of which is in the eastern mountainous area. The rest of the Province is flat with fertile soils and rivers. It is a major source of minerals, such as oil and coal. The climate is monsoonal, with a hot, wet summer and a cold winter.



LIAOXIORNIS

About the size of a hummingbird, *Liaoxiornis* was the smallest bird from the Cretaceous. Its feet could grasp a branch, so it could perch—most of the other early birds could not do this.

CONIFERS were the main trees

THE LIAONING FOREST

The area teemed with life. Trees and ground plants such as horsetails and ferns covered the land. The first flowering plants were just appearing, too.

CAUDIPTERYX

Discovered in 1998, this birdlike dinosaur had long feathers on its arms and tail. Unable to fly, its feathers may have been used to attract mates, like birds today, or to frighten rivals away.

SINORNITHOSAURUS

The downy fluff over much of its body, and long feathers on its arms, may have helped to keep this dinosaur warm. It was a dromaeosaur—a small, agile hunter with big eyes, sharp teeth, and curved claws on its hands and feet.

SINOSAUROPTERYX

With its back and tail covered in a coat of featherlike filaments up to 1½ in (4 cm) long, *Sinosauropteryx* proved that not all dinosaurs had reptilian, scaly skin.

DID YOU KNOW?

The Liaoning forest would have echoed to the clicks of cicadas, the croaks of frogs, and the buzz of dragonflies. Their fossils—and many more—have all been found there.

Gobi Desert

LOCKED INSIDE THE SANDSTONES of the Gobi Desert, Mongolia, are incredibly well-preserved dinosaur fossils of the Late Cretaceous. A stretch of rock 6 miles (10 km) long has yielded a snapshot of animal life from 75 million years ago, when the region was dry and sandy with little water. *Oviraptor* nested here, *Velociraptor* was the hunter, and herds of *Protoceratops* grazed on the low-lying ground, only to be entombed by sandstorms. Today, fossilized bones, eggs, and nests are found in the fire-red rocks of the Flaming Cliffs site.



▲ SITE LOCATION

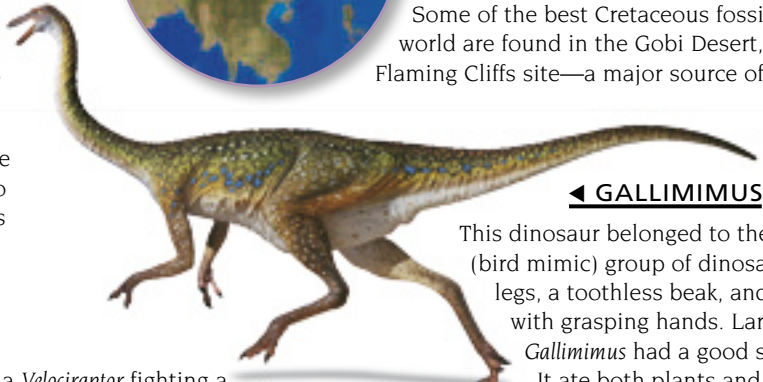
Some of the best Cretaceous fossil sites in the world are found in the Gobi Desert, including the Flaming Cliffs site—a major source of dinosaur fossils.



OVIRAPTOR laid clutches of 15 to 20 eggs, arranged in a circle

◀ OVIRAPTOR

A carnivorous dinosaur, *Oviraptor* had a birdlike appearance. It lived in groups, and built nests in the desert sand, which it seems to have sat on to keep its eggs warm until they hatched.



◀ GALLIMIMUS

This dinosaur belonged to the ornithomimid (bird mimic) group of dinosaurs. It had long legs, a toothless beak, and slender arms with grasping hands. Large eyes suggest *Gallimimus* had a good sense of vision. It ate both plants and meat.

▼ VELOCIRAPTOR

At Tugriign Us, fossils of a *Velociraptor* fighting a *Protoceratops* were discovered. Both seemed to have died in a sudden sandstorm while still locked in combat. *Velociraptor* would have been a deadly predator. It was armed with jaws that held about 80 sharp teeth, and a sickle-shaped claw on each foot for slashing its victims.



LONG, NARROW JAWS designed for biting and pulling at flesh

▲ GOBI DESERT

The Gobi Desert of central Asia stretches for 1,000 miles (1,600 km) across southeast Mongolia and northern China. It is an arid, inhospitable landscape, where temperatures are well below freezing at night, then become baking hot in the daytime sun.

Roy Chapman Andrews



Between 1919 and 1930, Roy Chapman Andrews (1884–1960) led expeditions to the Gobi Desert, where he discovered the first-known fossilized dinosaur nests, and new dinosaurs, including *Protoceratops*.



PROTOCERATOPS ▶

A ceratopsian (horned face), *Protoceratops* lived in herds, grazing on plants. It's thought to have been a slow walker, but like other ceratopsians it might have sprinted at 15 mph (25 kph) in short bursts to escape from danger.



STEP 1

FRONT LEGS bent at the elbow, enabling the dinosaur to steer, while the hind legs were held straight



STEP 2

RIGHT FRONT FOOT and left back foot moved at about the same time when walking

STEP 3

LEFT FRONT FOOT and right back foot followed to complete the walking sequence—in this way, the dinosaur always had two feet on the ground



Australia and Antarctica



For much of dinosaur history, the continent of Australia lay closer to the South Pole than it does today. It was connected to Antarctica, and both landmasses experienced cold temperatures and low levels of light. Despite these seemingly unsuitable conditions, dinosaurs, such as the big-eyed *Leaellynasaura*, lived in Earth's deep south, where they adapted to the long winter darkness. About 25 dinosaur locations are known from Australia, particularly in the northern state of Queensland and the southern state of Victoria. Four sites have been found on the coast and islands of Antarctica, though doubtless many more exist beneath the polar ice.

KEY	 TRIASSIC PERIOD	 SITE
	 JURASSIC PERIOD	 GLACIER
	 CRETACEOUS PERIOD	

LYSTROSAURUS

Length: 3 ft (1 m)
Pronunciation: liss-troh-sore-us
Meaning: "spoon lizard"

CRYOLOPHOSAURUS

Length: 24 ft (7.5 m)
Pronunciation: cry-o-loaf-oh-sore-us
Meaning: "frozen crested lizard"

ANKYLOSAUR (UNNAMED)

Length: unknown

LEAELLYNASAURA

Length: 3 ft (1 m)
Pronunciation: lee-ell-in-a-sore-a
Meaning: "Leaellyn's lizard" (after the finder's daughter)

PLIOSAUR (UNNAMED)

Length: 16 ft (5 m)

ATLASCOPCOSAURUS

Length: 9 ft (2.7 m)
Pronunciation: at-las-kop-koh-sore-us
Meaning: "Atlas Copco lizard"

MINMI

Length: 8 ft (2.5 m)
Pronunciation: min-mee
Meaning: named after Minmi Crossing, where it was found

THEROPOD (UNNAMED)

Length: unknown

HYPSILOPHODONT (UNNAMED)

Length: 15 ft (4.5 m)

MUTTABURRASAUROS

Length: 33 ft (10 m)
Pronunciation: mut-a-burr-a-sore-us
Meaning: "Muttaborra lizard"

TIMIMUS

Length: 10 ft (3 m)
Pronunciation: tim-ee-mus
Meaning: "Tim's mimic" (after the finder's son)

PAPUA
NEW GUINEA

QUEENSLAND FOSSIL TRIANGLE

Australia's finest examples of dinosaurs, such as the ankylosaur *Minmi*, have been found in this fossil location. In addition, more than 3,300 footprints have been discovered at Lark Quarry, near Winton.



FOSSIL OF MINMI

HUGHENDEN
CLONCURRY
WINTON
QUEENSLAND
FOSSIL TRIANGLE

AUSTRALIA

DINOSAUR COVE

NORTH
ISLAND

HAWKE BAY

NEW ZEALAND
SOUTH
ISLAND

NORTH ISLAND

New Zealand's first dinosaur fossils were uncovered in Hawke Bay by amateur paleontologist Joan Wiffen in 1979. So far, North Island is the only part of New Zealand to have yielded dinosaur fossils, many of which have not yet been named.



POLAR DINOSAURS

Antarctica was the very last continent to provide dinosaur evidence. The first fragmentary specimens were collected in 1986, on James Ross Island. Since then, other sites have been found.



MOUNT KIRKPATRICK

BEARDMORE GLACIER

ANTARCTICA

JAMES ROSS ISLAND
VEGA ISLAND

THE MAP

Major fossil locations are shown on this map, together with the prehistoric animals found there.

Dinosaur Cove

IN THE EARLY CRETACEOUS, about 110 million years ago, some dinosaurs lived in a polar environment, where there was total darkness for the months of winter and temperatures fell below zero. At this time, Australia lay within the Antarctic Circle, and dinosaurs that lived there were adapted to cold, dark winters followed by days of 24-hour sunlight in summer. *Leaellynasaura* was one of them, roaming in herds across a forested plain. Today, in an area of south Australia known as Dinosaur Cove, the fossils of *Leaellynasaura* as well as other dinosaurs and animals have been unearthed.



▲ SITE LOCATION

Dinosaur Cove, Victoria, is on the coast of southeast Australia, where the Otway Range meets the sea. The site is partway up a cliff.

TIMIMUS

Leg bones from an adult and a juvenile *Timimus* are all that has been found of this dinosaur. They are enough to identify it as a coelurosaur—a small, lightweight carnivore with slender legs.

ATLASCOPCOSAURUS

A small, two-legged plant-eater, *Atlascopcosaurus* lived in herds. Its long hind legs suggest that it was a fast-runner.

POLAR FOREST

The forest of conifers, ginkgoes, and monkey puzzle trees grew on a river floodplain. The understory was a carpet of ferns, horsetails, and mosses.

Patricia Vickers-Rich



Paleontologist Patricia Vickers-Rich (b. 1944) works at Monash University, Melbourne, Australia. She is married to Thomas Rich, a paleontologist at the Museum of Victoria, Melbourne. Their fieldwork in Australia has resulted in the discovery of dinosaurs *Leaellynasaura* and *Timimus*.

SPIDER

Spiders of all sizes are an example of the many kinds of invertebrates (creatures without backbones) that lived in the forest.



LARGE EYES would have helped *Leaellynasaura* to see in the dull light



WOODLICE

These insects lived on the decaying wood of fallen branches and dying trees, as their descendants do today.



LEAELLYNASAURA

Surviving the subzero temperatures of its polar home was this two-legged plant-eater. *Leaellynasaura* lived in groups, and was armed with good eyesight and self-sharpening teeth.



DINOSAUR COVE TODAY

Australia's Otway coastline has many bays. Some have narrow sandy beaches at their heads. Others, such as Dinosaur Cove, are framed by rugged sea cliffs, as seen here in the distance. It is these cliffs, formed from Early Cretaceous sandstones and mudstones, that contain the area's dinosaur fossils.

Fossil Triangle

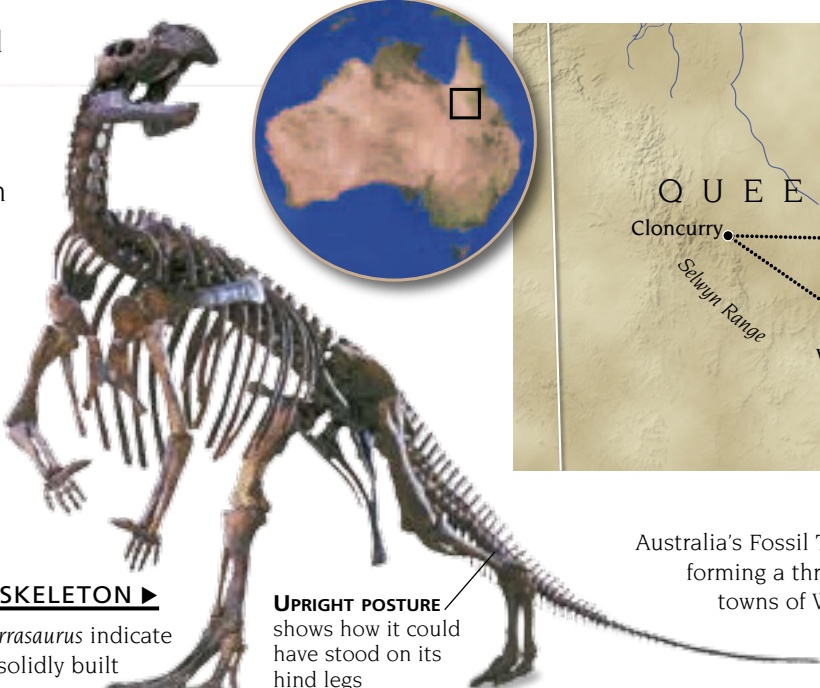
QUEENSLAND HAS PRODUCED FOSSILS of Early Cretaceous dinosaurs and other reptiles. About 100 million years ago, an area now known as the “Fossil Triangle” was covered by sea, as revealed by the fossils of pliosaurs found there. The bodies of land-dwelling dinosaurs are also in this area—perhaps the victims of floods that swept them into the sea. Eventually, the sea retreated, leaving its sediment to form soft limestone, from which *Minmi*, *Muttaburrasaurus*, and a near-perfect pliosaur have been excavated.



SNOUT BUMP contained an organ for making sounds

MUTTABURRASAUROS SKELETON ►

The heavy bones of *Muttaburrasaurus* indicate that it was a muscular, solidly built dinosaur. Behind its bony beak were cheek teeth designed for a cutting rather than a grinding action. This is surprising, as cutting teeth are usually found in carnivores, not herbivores.



UPRIGHT POSTURE shows how it could have stood on its hind legs

▲ MUTTABURRASAUROS

An ornithopod (bird-footed), *Muttaburrasaurus* may have lived in herds that traveled long distances in search of food. It moved on all fours, browsing on ferns, but it could have stood on its hind legs to reach cycads and conifers growing high above the ground.

DID YOU KNOW?

Minmi was the first armored dinosaur to be discovered south of the equator. It was named after the Minmi Crossing in southeastern Queensland, where the fossil was found. *Minmi* is an aboriginal word, referring to a large water lily.

MINMI ►

This tanklike, four-legged ankylosaur was a plant-eater. Too slow to escape from a predator, it relied upon the rows of spikes that jutted out from its tough hide.



SPIKES, or bony plates, protected most of the dinosaur's body

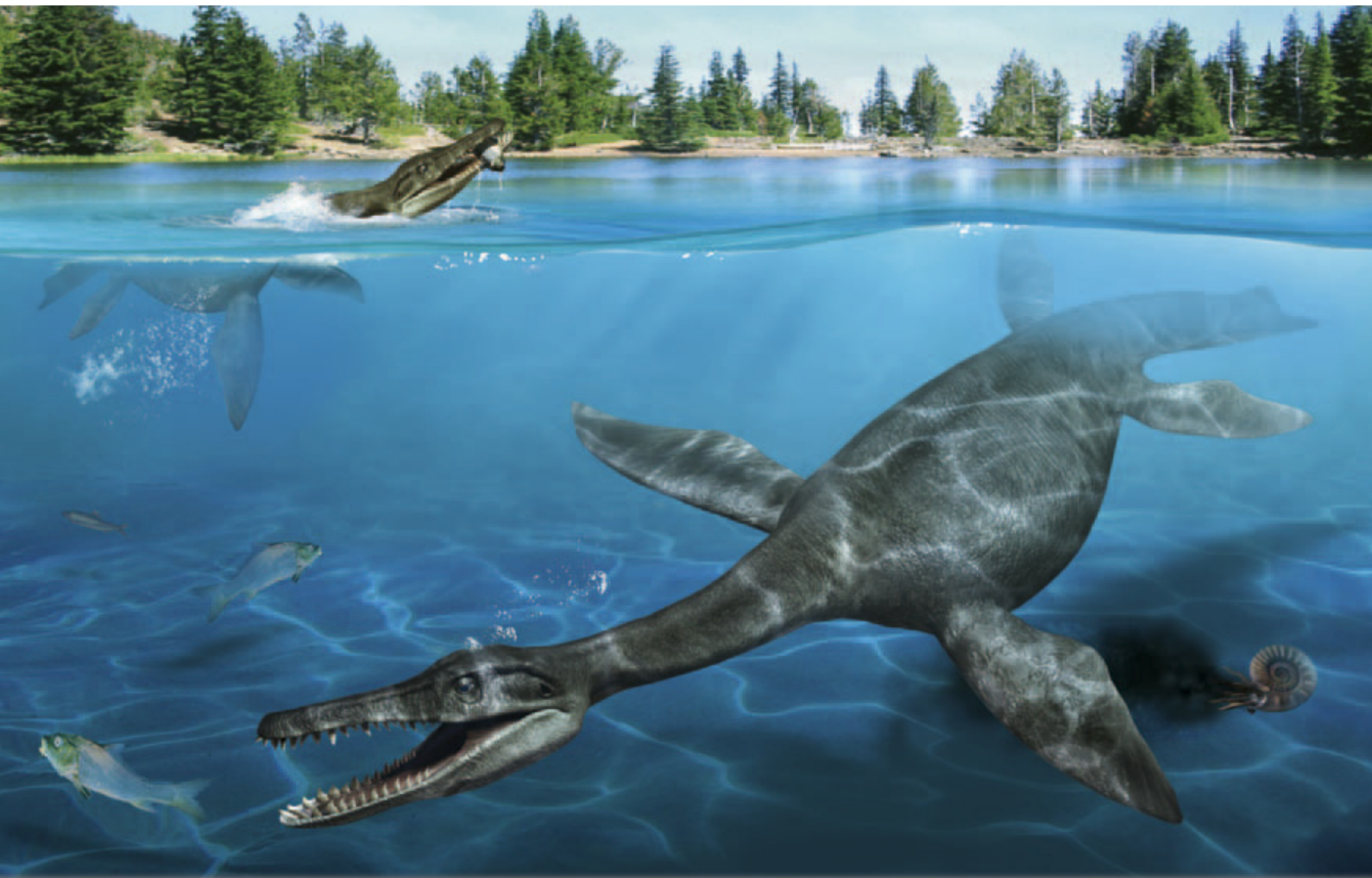
▲ QUEENSLAND OUTBACK TODAY

Queensland's landscape is one of opposites, from the semiarid western outback region—home of the “Fossil Triangle”—to the coastal wetlands and swamps of the tropical northern zone.



▲ SITE LOCATION

Australia's Fossil Triangle is in northern Queensland, forming a three-sided area between the outback towns of Winton, Hughenden, and Cloncurry.



► RICHMOND PLIOSAUR

A near-complete skeleton of a small pliosaur was found near the town of Richmond, on the northern edge of the Fossil Triangle. Known as the “Richmond Pliosaur,” it is one of the world's best-preserved pliosaurs. Shown here is an illustration of how a pliosaur might have moved—scientists think it used its flippers to swim like a sea lion.



DOWNWARD—powerful flippers may have been used to propel the pliosaur through the water as they moved down forcefully

BACKWARD—flippers are now raised slightly upward, as the backward push through the water begins

FORWARD—flippers are now fully pushed back and then brought forward, enabling the pliosaur to start the cycle again

Antarctica

WHEN DINOSAURS WERE ALIVE, Antarctica was a warm, ice-free place, lying farther north than now. *Cryolophosaurus*, an Early Jurassic carnivorous dinosaur of 195 million years ago, and older Triassic reptiles such as *Lystrosaurus* were found here in the 1990s, in the vicinity of Mount Kirkpatrick. They had lived beside a river on a low-lying woodland plain. Long after they ceased to exist, the Earth's temperature cooled, glaciers spread, and the land was pushed up to form today's ice-capped mountains of Antarctica.

◀ CRYOLOPHOSAURUS SKELETON

An almost complete *Cryolophosaurus* skull, together with other parts of its skeleton, was found high up near the summit of Mount Kirkpatrick. The skull, which is similar to that of *Allosaurus*, measures 25 in (65 cm) long, and its jaws hold many backward-pointing teeth with serrated edges—the teeth of a predatory meat-eater.

CRYOLOPHOSAURUS ▶

The distinguishing feature of *Cryolophosaurus* was its bony head crest and short horns that grew between its eyes. The crest may have been used during courtship displays to attract a mate or to warn rivals away. The bone was thin and fragile, so the crest would not have functioned as a weapon.

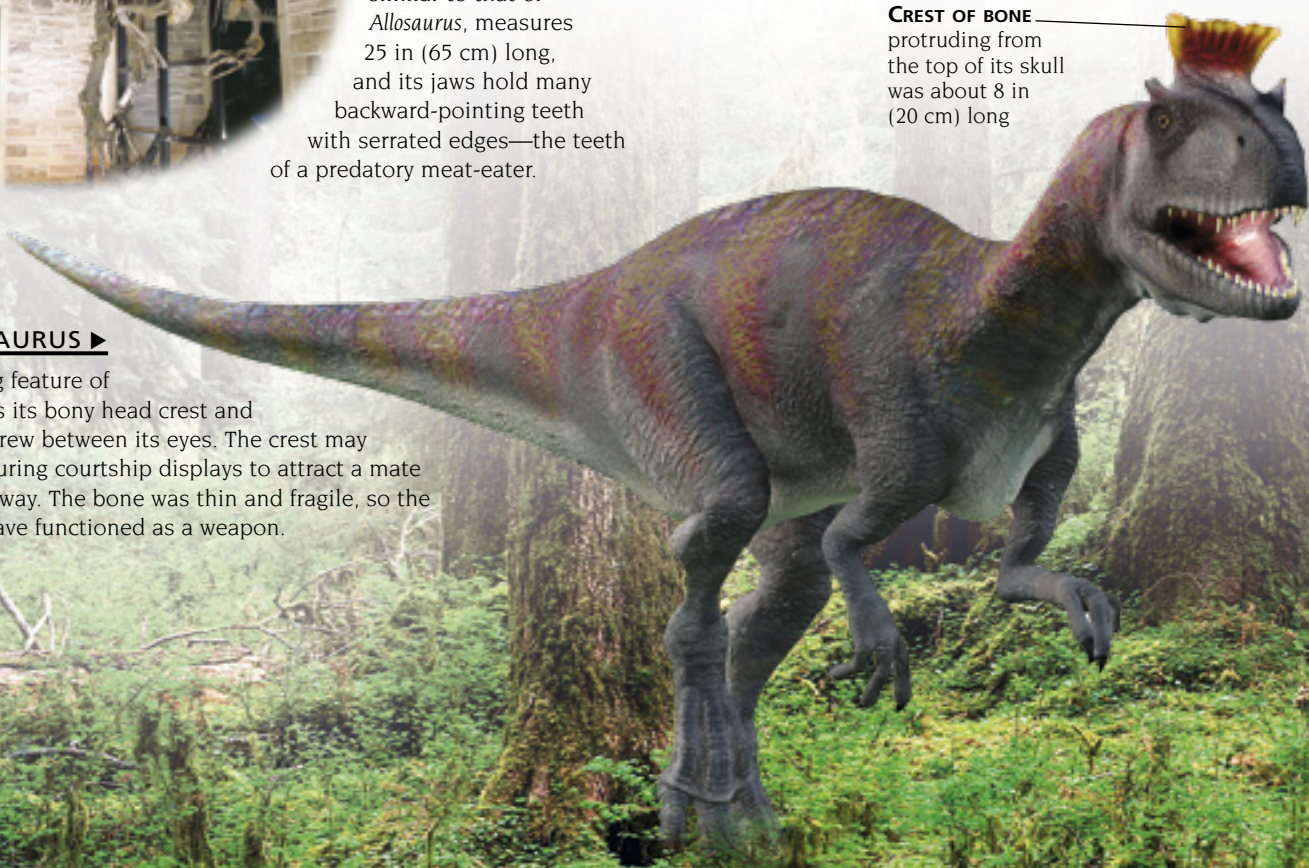


▲ SITE LOCATION

Mount Kirkpatrick lies close to the Beardmore Glacier, one of the world's largest valley glaciers.



CREST OF BONE
protruding from
the top of its skull
was about 8 in
(20 cm) long



▲ MOUNT KIRKPATRICK REGION TODAY

At 14,855 ft (4,528 m) Mount Kirkpatrick is the highest peak in the Queen Alexandra mountain range. As it is mainly free of ice, it is the major source of Antarctica's fossils, which are mixed among its scree and gravel.



▲ FOSSIL FERN FROND

Although ferns do not grow on Antarctica today, they did when dinosaurs lived there. The fossil fern frond shown above was found among the rocks as evidence. Ferns provided plant-eaters with a rich source of food.



▲ LYSTROSAURUS

This strange-looking animal was not a dinosaur. It was a therapsid—an animal with a mammal-like skull and a reptilelike walk. *Lystrosaurus* was a plant-eater, had short tusks, and was capable of digging burrows.

POWERFUL FORELIMBS may have been used for digging into the soft ground

William Hammer



A paleontologist at Augustana College, Illinois, William Hammer (b. 1950) has made many field trips to Antarctica. In 1991 he excavated *Cryolophosaurus*—Antarctica's first dinosaur and the only theropod that has not been found on any other continent. His work has identified other dinosaur species, including a prosauropod, a pterosaur, and mammal-like reptiles.

CRYLOPHOSAURUS was a two-legged carnivore and, although smaller, it may have looked similar to *Allosaurus*



SHORT HORNS
each side of the
head crest

Islands of Antarctica

DINOSAUR FOSSILS HAVE BEEN DISCOVERED on two of Antarctica's islands. The bone fragments that have been collected from James Ross Island and Vega Island belong to the Late Cretaceous world. Imagine a woodland environment where a meat-eating dinosaur stalked its prey (or scavenged on the body of an already dead animal), scaring a herd of timid, ostrichlike hypsilophodonts that ran for their lives past a slow-moving ankylosaur. This was the Antarctica of about 80 million years ago. In recent years, teams of paleontologists have begun to reveal this lost world. In areas not covered by snow and ice, they scour the rocky terrain for evidence of dinosaurs.

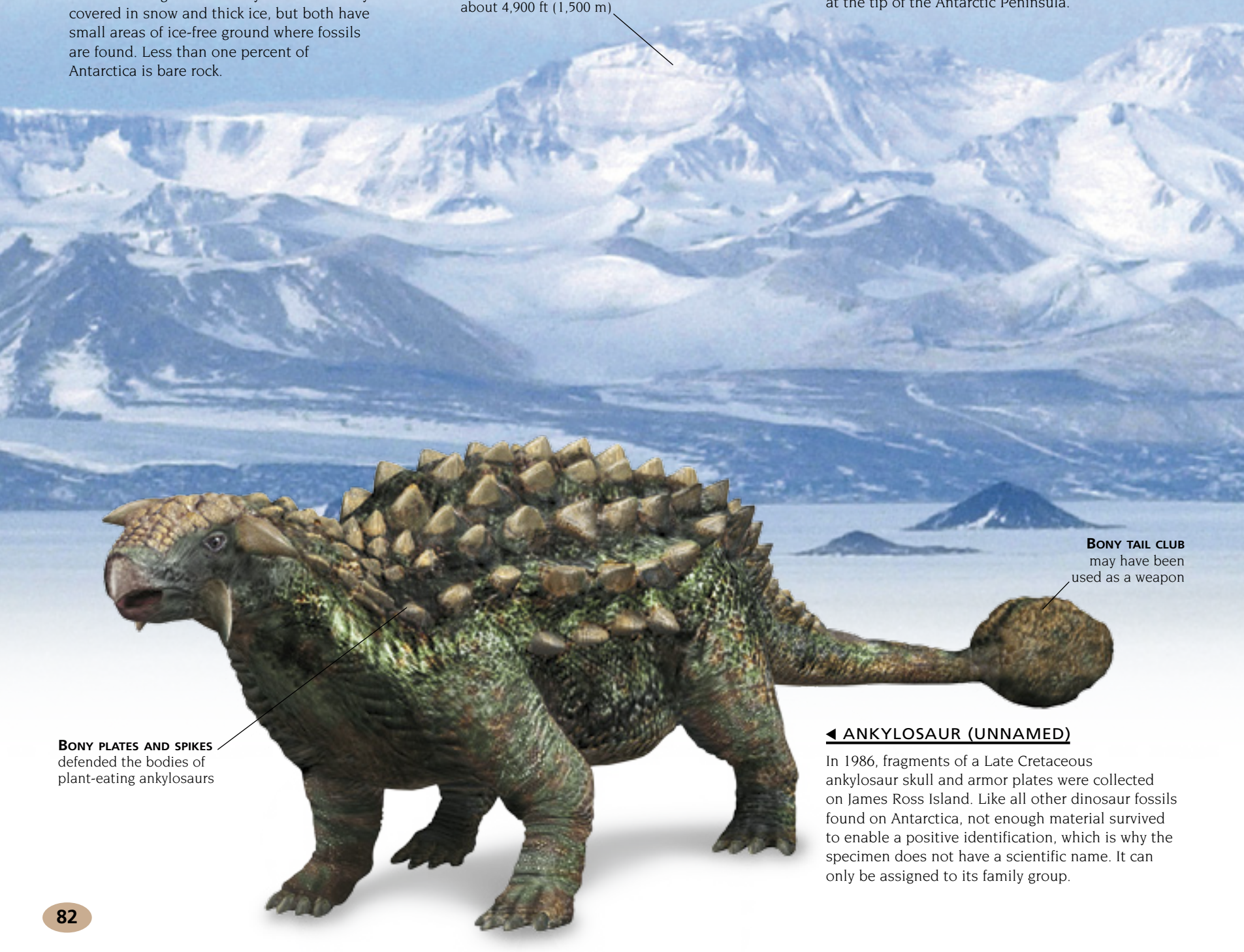
▼ **ICY ISLAND LANDSCAPE**

Antarctica has many islands, most of which lie close to the mainland, as do James Ross Island and Vega Island. They are almost fully covered in snow and thick ice, but both have small areas of ice-free ground where fossils are found. Less than one percent of Antarctica is bare rock.

JAMES ROSS ISLAND rises to a height of about 4,900 ft (1,500 m)

▲ **SITE LOCATION**

James Ross Island and the smaller Vega Island nearby lie off the northern coast of Antarctica, at the tip of the Antarctic Peninsula.



BONY PLATES AND SPIKES defended the bodies of plant-eating ankylosaurs

BONY TAIL CLUB may have been used as a weapon

◀ **ANKYLOSAUR (UNNAMED)**

In 1986, fragments of a Late Cretaceous ankylosaur skull and armor plates were collected on James Ross Island. Like all other dinosaur fossils found on Antarctica, not enough material survived to enable a positive identification, which is why the specimen does not have a scientific name. It can only be assigned to its family group.

▼ AMMONITE

Ammonite fossils have been found on Vega Island. These swimming mollusks, related to today's squid and octopuses, were one of the most common animals in Jurassic and Cretaceous seas. There were many different species, and all were preyed on by ichthyosaurs, plesiosaurs, and other marine reptiles.



TIGHTLY COILED SHELL
had a ribbed surface

SHAPE OF THE TEETH
helps paleontologists
to recognize a theropod

SIEVING SCREE
to collect fossil
fragments



◀ POLAR EXCAVATION

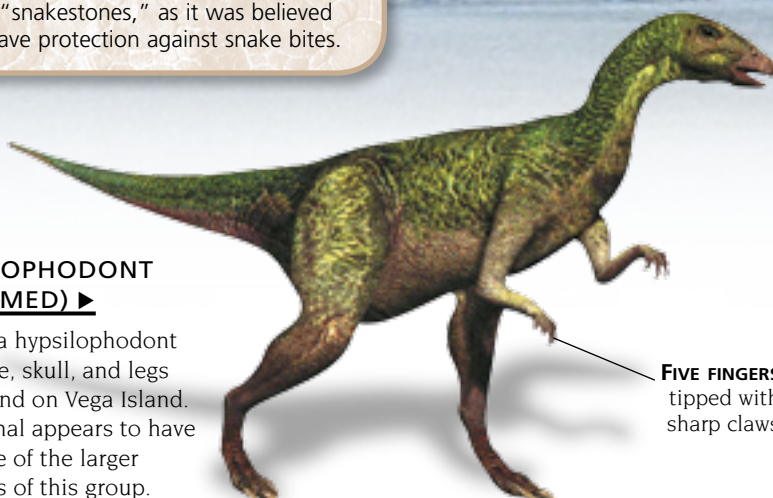
Paleontologists who work on Antarctica and its islands face many difficulties. Their fieldwork season is limited to a short time during the continent's brief summer, and the fossils they collect are found scattered, broken, and worn among the gravels of ancient stream beds.

DID YOU KNOW?

- Ammonites varied in size. Some grew no bigger than a human fingernail, while others reached 6½ ft (2 m) in diameter.
- In European folklore, ammonites were called "snakestones," as it was believed they gave protection against snake bites.

HYPSILOPHODONT (UNNAMED) ▶

Parts of a hypsilophodont backbone, skull, and legs were found on Vega Island. The animal appears to have been one of the larger members of this group.



FIVE FINGERS
tipped with
sharp claws



SMALL TOE
or dewclaw at
the back of the foot

▲ THEROPOD (UNNAMED)

In 2003, a trail of gastroliths (stomach stones) were found scattered on James Ross Island. They led paleontologists to the remains of the meat-eating dinosaur they came from. The team collected much of its lower legs, parts of its backbone, skull fragments, and bits of teeth. They belong to a new carnivore, which was 6–8 ft (1.8–2.4 m) tall.



Dinosaur Facts

THE MORE WE FIND OUT ABOUT DINOSAURS, the more we want to know. Why did they disappear from the face of the Earth, and what kinds of animals replaced them? How do paleontologists find and excavate their fossil remains, and how do they figure out what they looked like when they were alive? Some of these questions are easier to answer than others, but the next few pages give some of the facts and theories about the life and death of these amazing prehistoric creatures.





GLOBAL DESTRUCTION

The gas and searing hot debris hurled into the sky by the impact of a giant asteroid would have caused months of darkness, acid rain, and global wildfires. Plant life was destroyed, and dinosaurs like these *Triceratops* would have starved.

Death of the Dinosaurs

THE DINOSAURS FLOURISHED for 165 million years. But then, some 65 million years ago, they seem to have died out almost overnight. In reality, this mass extinction may have taken place over several thousand years, which is no more than an instant in geological time. Yet there is evidence that the main agent of their destruction was an asteroid impact so devastating that it wrecked the global ecosystem within a few days. Some animals survived the cataclysm, but the giant dinosaurs were wiped out.

DEBRIS PLUME rose high into space, enveloped the planet, and was eventually deposited in a thin layer around the whole world



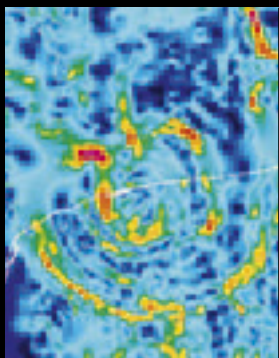
◀ IMPACT ZONE

In 1990 a huge impact crater was discovered at Chicxulub on the coast of Yucatán, Mexico. It dates from 65 million years ago, and since it is 110 miles (180 km) across, it must have been made by an asteroid big enough to cause global catastrophe.

MOMENT OF IMPACT ▶

The size of the Chicxulub crater indicates that it was made by an asteroid some 6 miles (10 km) across, which struck the Earth at a speed of about 62,000 mph (100,000 kph). The impact caused a colossal explosion that instantly vaporized the asteroid, hurling a vast plume of hot gas and debris into the atmosphere.





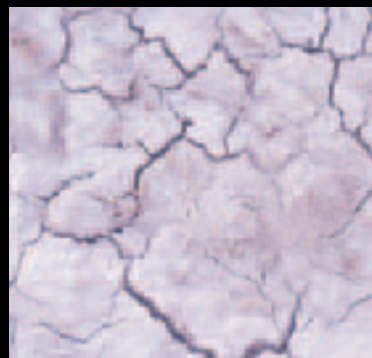
CRATER GRAVITY MAP



CLAY LAYER

◀ FALLOUT

The Chicxulub impact crater is buried beneath later sediments, but it shows up clearly in gravity maps of the area. The vast amount of material ejected by the explosion settled all over the world as a thin layer of clay that divides rocks of Cretaceous and Tertiary ages. The clay is rich in iridium—a rare mineral that is usually found only in meteorites.

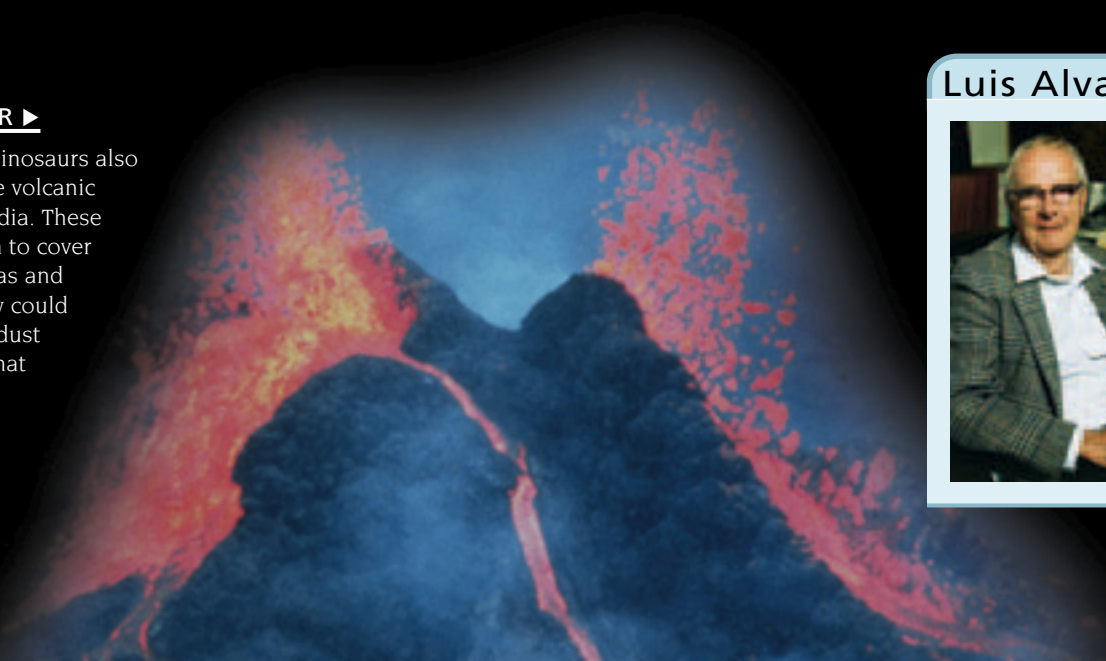


◀ CLIMATE CHANGE

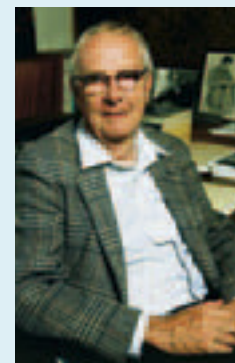
The asteroid impact certainly happened, but it may be only part of the story. The dinosaurs may also have been hit by climate change caused by increased carbon dioxide in the atmosphere. Released by huge volcanoes, the gas trapped heat radiated from Earth, raising temperatures and creating a global desert.

VOLCANIC WINTER ▶

The extinction of the dinosaurs also coincides with massive volcanic eruptions in central India. These generated enough lava to cover an area the size of Texas and Alaska combined. They could have thrown so much dust into the atmosphere that sunlight was blotted out, making the planet too cold for large reptiles.



Luis Alvarez



The impact theory was suggested in 1980 by physicist Dr. Luis Alvarez (1911–1988) and his son Walter (b. 1940), a geologist. They discovered the thin layer of iridium-enriched clay that is evidence of an asteroid strike.

After the Dinosaurs

IF THE IMPACT THEORY OF DINOSAUR EXTINCTION is correct, life on Earth must have suffered a catastrophic blow at the end of the Cretaceous Period. Yet although all the big dinosaurs, flying pterosaurs, and marine reptiles died out, many other types of animal lived on into the Tertiary Period. The reason for their survival is still uncertain. They may have been protected by their biology or their habitats, or the extinction may have been a much more gradual, selective process. Either way, the survivors were the ancestors of the animals that live on Earth today.

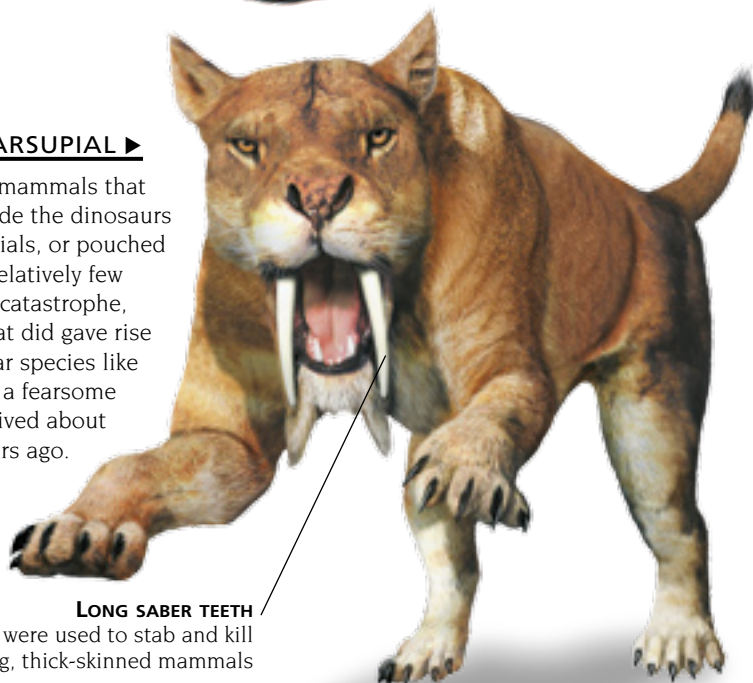
◀ MAMMAL SURVIVORS

Mammals had existed throughout the dinosaur era, but they were small, probably secretive creatures. Many forms were eliminated in the mass extinction, but some survived and started evolving into a much wider variety of species, including early primates like this *Plesiadapis*.



KILLER MARSUPIAL ▶

Many of the mammals that lived alongside the dinosaurs were marsupials, or pouched mammals. Relatively few survived the catastrophe, but those that did gave rise to spectacular species like *Thylacosmilus*, a fearsome hunter that lived about 6 million years ago.



LONG SABER TEETH
were used to stab and kill big, thick-skinned mammals



SHORT WINGS
were far too small for flight, but were armed with sharp claws

◀ FEATHERED DINOSAUR

There is evidence that the ancestors of birds were carnivorous dinosaurs like *Velociraptor*. If so, then these “feathered dinosaurs” lived on after the extinction. Some evolved into giant, flightless hunters such as this *Titanis*, which stood 8 ft (2.5 m) high. It lived 2 million years ago, and probably hunted by running down its prey and killing it with its huge hooked beak.

POWERFUL LEGS
enabled *Titanis* to run at high speed, like a modern ostrich

▲ FORESTS AND GRASSLANDS

The Early Tertiary was a hot period when much of the world was covered by tropical forest. But by the Late Tertiary, about 10 million years ago, the climate had cooled and the forests were giving way to open grasslands.

HEAVY TAIL

balances the kangaroo when it is bounding across the plains on its hind legs

▲ ATHLETIC GRAZERS

The open plains that appeared in the Late Tertiary were colonized by mammals that were able to eat grass. Since they had nowhere to hide, many developed ways of moving fast to escape danger, such as the hopping technique of a modern kangaroo.

STREAMLINED BODY and powerful muscles enable a dolphin to swim like a shark

MASTERS OF THE AIR ▶

Like the mammals, birds evolved many forms during the post-dinosaur era. Their feathers and lightweight skeletons made them ideally equipped for flight, and their mastery of the air has enabled them to exploit a wide range of habitats. Some, like this parrot, are among the most colorful of all animals.

LONG FLIGHT FEATHERS extend the parrot's forelimbs into superbly efficient wings

▲ SLEEK SUCCESS

The mammals have diversified to fill every habitat left vacant by the extinct dinosaurs, pterosaurs, and marine reptiles. Most live on land, but bats have taken to the air, and whales and dolphins spend their entire lives at sea. These dolphins may look like fish, but in many ways they are the modern counterparts of the Jurassic *Ichthyosaurus*.

Questions You Ask

THERE ARE MANY THINGS that we still do not know about dinosaurs. The evidence of their fossil remains is often confusing, and some features can be interpreted in more than one way. But every time a new fossil is found, it adds another piece to the jigsaw. Gradually, piece by piece, we are building up a complete picture of how these astonishing animals lived and died.



DR. ROBERT PLOT

Q Who discovered the first dinosaur?

A There are accounts of giant fossilized bones in ancient Chinese, Greek, and Roman texts. The Chinese believed they were the bones of dragons, and they were not far wrong. The first picture of a dinosaur bone appeared in 1676, in a book by Dr. Robert Plot, an English historian. He assumed it was the thighbone of an elephant.

Q What was the first named dinosaur?

A In 1824 the geologist and fossil hunter William Buckland published a scientific account of the partial remains of a large meat-eating reptile, which he had discovered near Oxford, England, five years earlier. He named it *Megalosaurus*, which simply means “big reptile.”



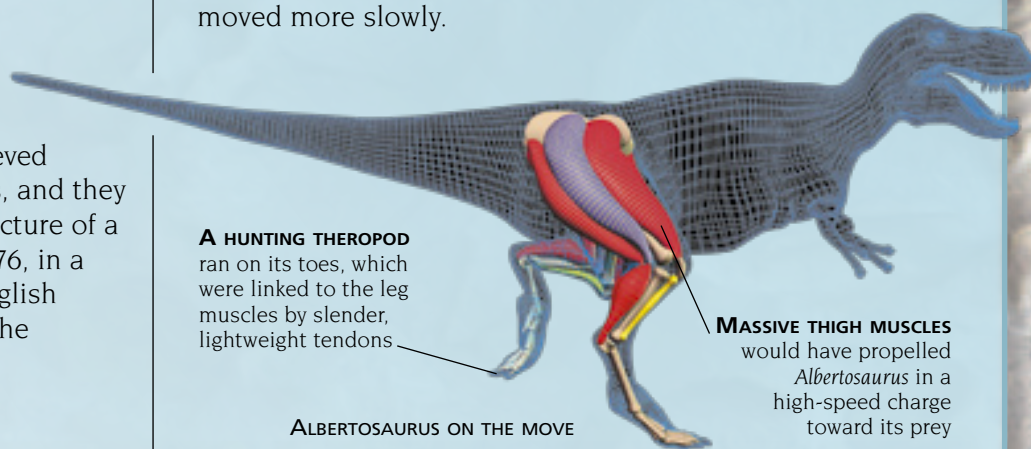
PARTS OF THE FOSSILIZED MEGALOSAURUS JAW

Q How many different dinosaurs were there?

A Nobody knows. About a thousand species have been found and named, but many more probably await discovery. Some fossils of the same species may also have been given different names.

Q How fast did dinosaurs move?

A Meat-eating theropods like *Albertosaurus* stood on their hind legs, and their leg bones show that they had a long stride like a modern ostrich. The muscle scars on their bones also show that they had an ostrichlike running action, so they could probably run quite fast—at least in short bursts. Big sauropods that stood on four feet, such as *Argentinosaurus*, would have moved more slowly.



A HUNTING THEROPOD ran on its toes, which were linked to the leg muscles by slender, lightweight tendons

MASSIVE THIGH MUSCLES would have propelled *Albertosaurus* in a high-speed charge toward its prey

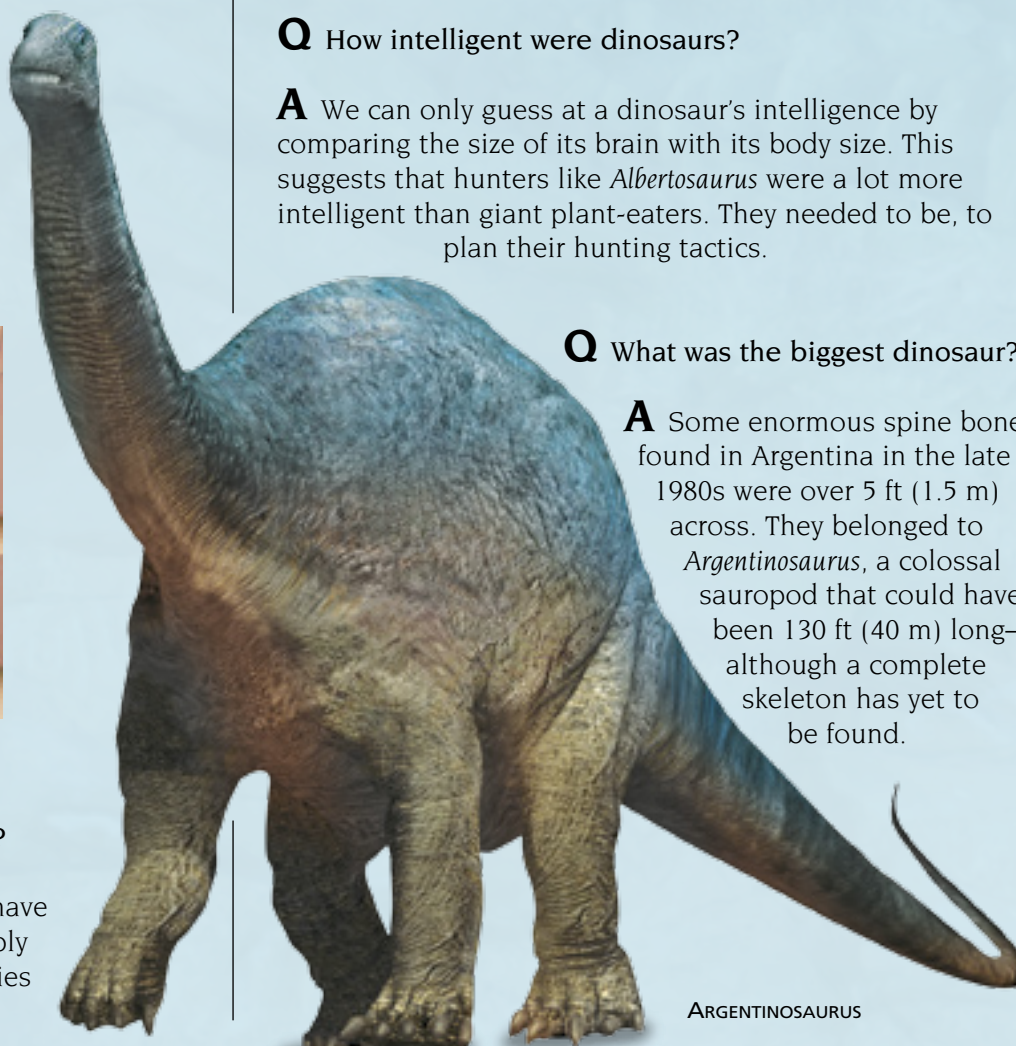
ALBERTOSAURUS ON THE MOVE

Q How intelligent were dinosaurs?

A We can only guess at a dinosaur's intelligence by comparing the size of its brain with its body size. This suggests that hunters like *Albertosaurus* were a lot more intelligent than giant plant-eaters. They needed to be, to plan their hunting tactics.

Q What was the biggest dinosaur?

A Some enormous spine bones found in Argentina in the late 1980s were over 5 ft (1.5 m) across. They belonged to *Argentinosaurus*, a colossal sauropod that could have been 130 ft (40 m) long—although a complete skeleton has yet to be found.



ARGENTINOSAURUS

Q What was the smallest dinosaur?

A The smallest dinosaur discovered so far is *Microraptor*, a birdlike hunter that was just 30 in (77 cm) long from its nose to the tip of its long tail. Found in China in 2001 and 2002, its fossils show the impressions of long feathers on its limbs, suggesting that it could glide through the air.

Q Did dinosaurs make sounds?

A Some dinosaur skulls have big, bony crests that may have been used to make noises. The crest of *Parasaurolophus* was linked to its nostrils, and by blowing air through it, scientists have produced a trumpeting sound like that of an elephant.



FIELD-WORKER EXCAVATING DINOSAUR BONES

Q How do paleontologists know where to look?

A Dinosaur fossils have been found all over the world. Many have been discovered by accident, but the geology of each site often suggests where other fossils may lie. The most productive rocks are those that formed on land or in shallow fresh water, because dinosaurs were land-dwelling animals.

Q What was dinosaur skin like?

A Some rare dinosaur fossils include impressions of the animal's skin. They show that many dinosaurs were scaly, like modern reptiles, but some, like *Velociraptor*, seem to have been partly covered in feathers or down—possibly for insulation.

Q Were dinosaurs warm- or cold-blooded?

A Giant plant-eaters were probably cold-blooded like modern reptiles. Small meat-eaters could have been warm-blooded, like birds, since this would make them more agile. Insulating feathers would help them conserve heat.

Q Can you tell if a dinosaur is male or female?

A The skulls of some herd-living dinosaurs such as *Protoceratops* are of two types. Some are larger and more elaborate and probably belonged to males that competed for females, just like stags with their large antlers.

Q Why are smoothed stones sometimes found with dinosaur bones?

A Many plant-eating dinosaurs swallowed stones (gastroliths) deliberately. The stones settled in a muscular stomach, or gizzard, where they were ground together to mash the tough plant fiber to a pulp, becoming polished in the process. Chickens swallow grit for the same reason.



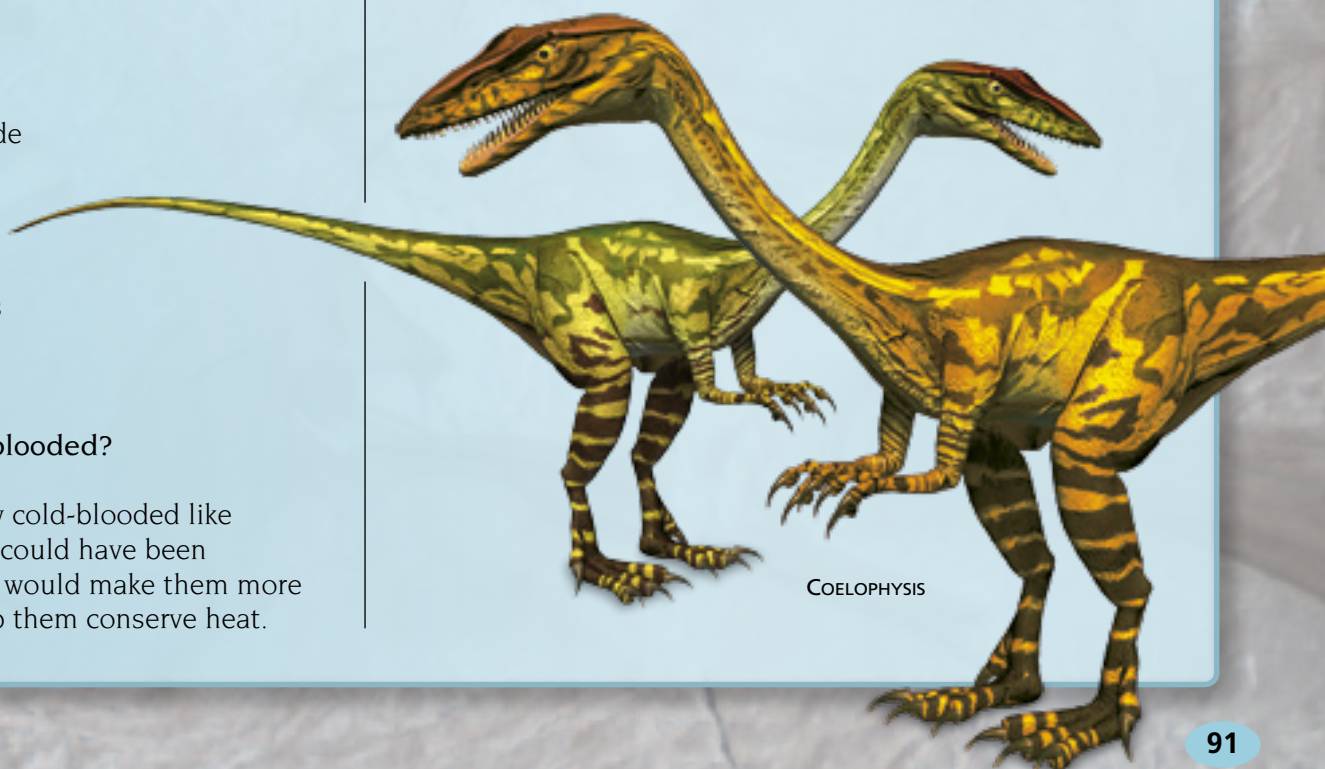
GASTROLITHS

Q How long did a dinosaur live?

A A big, slow, cold-blooded sauropod may have had a maximum lifespan of about 200 years, but a fast-living, warm-blooded hunter would have died much younger. In practice, few dinosaurs would have died of old age. Disease, injury, or hungry predators got them first.

Q What color were dinosaurs?

A Dinosaurs were once portrayed in drab greens and browns, but they could have been brightly patterned. The males, in particular, may have sported vivid courtship colors, just like many male birds today. Females of smaller species were more likely to be well camouflaged.



COELOPHYSIS

Excavation and Display

WHEN A DINOSAUR FOSSIL IS DISCOVERED, it is usually a confusing mess of bones that have been pulled apart by scavengers or swept into a heap by the elements. Once the bones are exposed, the first job is to record their exact positions and any details of the site, since this may provide valuable clues about the animal's anatomy or life. Only then can excavators carefully remove the fossils, clean them up in the laboratory, and analyze and preserve them. They may then be used to make a replica skeleton for display in a museum.

▼ EXPOSING THE BONES

The bones are usually buried beneath layers of rock. The upper layers may be scraped off by machines, but the excavators remove the lower layers very carefully, using fine hand tools. They then place a wire grid over the exposed bones to divide the site into smaller areas that can be accurately mapped. Every bone is numbered and photographed.

▼ REMOVING THE BONES

Dinosaur fossils are often fragile, so each one is painted with resin, wrapped in cloth, and coated with wet plaster to strengthen it. When the plaster sets, the excavator can dig beneath the bone to remove it, and plaster the other side.

A SAUROPOD LIMB BONE is being carefully coated with plaster



▲ IN THE LABORATORY

Encased in its plaster field jacket, the bone is taken to the laboratory where the plaster is cut off with a special saw. The technicians then get to work on the fossil, using small pneumatic drills to remove surplus rock.

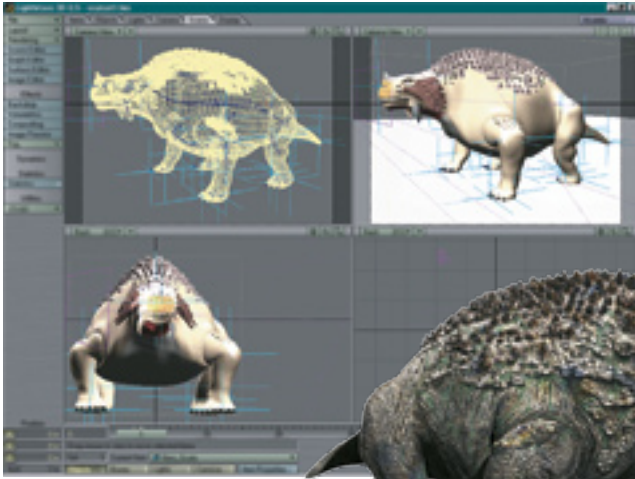


▲ FINE CLEANING

The fossil is carefully cleaned up using a variety of tools. This technician is working on *Tyrannosaurus* teeth with a vibrating needle, but other methods include blasting fossils with compressed air containing soda crystals.

REPLICA SKELETONS ►

Most dinosaur fossils are too fragile to be reconstructed into whole skeletons, and some bones may be missing. Exhibits like this spectacular, rearing *Barosaurus* in the American Museum of Natural History are built up from replica bones made from the fossils.

**▲ COMPUTER MODELING**

Paleontologists can use computers to reconstruct dinosaurs on screen, using data from the fossils. They can also use medical scanning techniques to see inside fossils, and reveal things like the embryos inside fossilized dinosaur eggs.

**▲ VIRTUAL REALITY**

Computer reconstruction enables paleontologists to show how dinosaurs like this *Tyrannosaurus rex* moved when they were alive, providing insights into how they may have behaved. This work has been the basis of several television programs depicting dinosaurs as living animals rather than fossils.

CREATING BAROSAURUS

Reconstructing a skeleton involves making exact replicas of all the fossil bones. The paleontologists also replace any that are missing, basing them on the fossils of related animals.

**▲ DINOSAUR MOLDS**

Each fossil bone is covered with a thick layer of liquid rubber. When it has set, the rubber is peeled away in two halves and reinforced with cloth and plastic.

**▲ PREPARING FOR CASTING**

The outside of each rubber mold is stiffened with fiberglass. The inside is then painted with the liquid plastic that will form the surface of the replica bone.

**▲ MAKING THE CAST**

The molds are fitted together, and liquefied foam plastic is poured into the cavity. This forms the strong but lightweight core of each replica bone.

**▲ THE REPLICA BONES**

When the plastic has solidified, the molds are carefully eased away. The replica bones are cleaned, painted, and assembled on a strong metal framework.

Glossary

AMBER

A sticky resin produced by certain trees. Insects and other organisms have been found fossilized in amber.

AMMONITE

A mollusk that lived in a coiled shell that had air-filled chambers—the mollusk lived in the outer chamber. Ammonites became extinct at the end of the Cretaceous Period.

AMPHIBIAN

An animal with a backbone and four legs that lays its eggs in water. In the larval (young) stage it lives in water. In the adult stage it lives on land and in water. Modern amphibians include frogs and toads.

ANAPSID

A reptile, such as a turtle, whose skull does not have an opening behind the eye.

ANKYLOSAUR

An armored plant-eating dinosaur covered with bony plates, knobs, and spikes. It also had a bony club at the end of its tail.

BEAK

A horny mouthpart on birds and some dinosaurs. Beaks are used in the same way as teeth, to hold and chop up food, but are lighter.

BONE BED

A layer of rock that contains a very large number of bones.

CARNIVORE

An animal that eats mainly meat.

CERATOPSIAN

A large, plant-eating dinosaur with pointed horns and a bony frill growing from the back of its skull.

CHEEK TEETH

Teeth used for chopping or chewing by plant-eaters. They were located behind the front teeth or beak.

COLD-BLOODED

When an animal, such as a lizard or a snake, cannot control its own body temperature but must rely on the heat of the Sun to warm it.

CONIFER

An evergreen tree or shrub, such as fir and pine, that produces seed cones.

CONTINENT

A large landmass, for example, Asia, Africa, North America, South America, Antarctica, Europe, and Australia.

CONTINENTAL DRIFT

The movement of continents across the surface of the Earth over time.

COPROLITE

Fossilized animal dung, or droppings.

CRETACEOUS PERIOD

Period of geological time from 140 to 65 million years ago.

CYCAD

A nonflowering plant with a thick trunk, no branches, and palmlike leaves.

DIAPSID

A reptile, such as a lizard, whose skull has two openings on either side.

DNA (DEOXYRIBONUCLEIC ACID)

Genetic material that determines the inherited characteristics in every living thing.

DROMAEOSAUR

A birdlike theropod dinosaur with a lightweight, agile body. Most were no bigger than 6 ft (1.8 m).

EMBRYO

An animal or a plant in the early stages of its development from an egg or seed.

EXTINCTION

Death of every single one of an animal or plant species.

FAMILY

A group of animals or plants that are related to each other.

FERN

A nonflowering plant with finely divided leaves called fronds.

FIBULA

The smaller of the two bones of the lower leg, the other being the tibia.

FLOODPLAIN

Flat landscape around a river, formed when the river bursts its banks and deposits sediment on the land.

FOOD CHAIN

A linked series of living things (animals and plants), each of which is the food for the next in line.

FOSSIL

The remains of an animal or plant that have been preserved in rock. Dinosaur fossils include bones, teeth, footprints, coprolites, gastroliths, eggs, and skin impressions.

FOSSIL FUEL

Fuel, such as coal, gas, or oil, composed of the fossilized remains of plants and animals.

GASTRALIA

Ribs in the belly area that are not attached to the backbone.

GASTROLITHS

Smooth, rounded stones found in the stomachs of some plant-eating dinosaurs that helped them break down and digest vegetation.

GINKGO

A primitive tree that shed its leaves in the fall. It had fan-shaped leaves. The only living species of ginkgo is the maidenhair tree.

GONDWANA

The southern supercontinent made up of Africa, Australia, Antarctica, South America, and India.

HADROSAUR

A large, plant-eating dinosaur with a long, flat beak. Many had crests on their heads.

HATCHLING

An animal just hatched from an egg.

HERBIVORE

An animal that only eats plants.

HORSETAIL

A primitive plant (related to ferns) with an upright stem and tiny leaves.

HYPSILOPHODONT

A fast-moving, plant-eating dinosaur with a stiff tail.

ICHTHYOSAUR

A sleek, fast-swimming reptile, similar in appearance to a dolphin.

IGUANODONT

A plant-eating dinosaur with hooflike nails on its hind feet and spikes on its hands.

INVERTEBRATE

An animal without a backbone.

JURASSIC PERIOD

Period of geological time from 205 to 140 million years ago.

LAURASIA

The northern supercontinent made up of North America, Europe, and Asia.

LIMESTONE

A sedimentary rock made from calcium carbonate minerals.

MAMMAL

A warm-blooded animal with a backbone and hair that gives birth to live young and feeds them on milk.

MAMMAL-LIKE REPTILE

Primitive reptile with some mammal-like features, such as hair and teeth, that lived before the dinosaurs.

MESOZOIC

The middle era of life, from 251 to 65 million years ago. Subdivided into the Triassic, Jurassic, and Cretaceous Periods.

MOSASAUR

A large marine reptile with long jaws and a slender body. It was a ferocious predator.

NODOSAUR

An armored dinosaur covered with bony plates, spikes, and knobs.

ORDER

A group of related families. There are two orders of dinosaurs—ornithischians and saurischians.

ORNITHISCHIANS

One of the two major orders of dinosaurs. They had a birdlike pelvis. This order includes horned dinosaurs, armored dinosaurs, and stegosaurs. All were plant-eaters.

ORNITHOMIMID

A fast-running, meat-eating dinosaur with a long neck and slender legs, similar in appearance to a present-day ostrich.

ORNITHOPOD

A two-legged, plant-eating dinosaur, some of which had crests on their heads.

PACHYCEPHALOSAUR

A two-legged, plant-eating dinosaur with a thick skull.

PALEONTOLOGIST

A scientist who studies the forms of life that existed in former geological periods.

PANGAEA

The single land mass or supercontinent of the Permian Period. It began to break up during the Triassic Period. It means “All Earth.”

PLESIOSAUR

A swimming reptile with paddlelike limbs that lived in the world’s seas during the Jurassic and Cretaceous Periods.

PREDATOR

An animal that kills other animals (prey) for food.

PREY

Animals hunted and eaten by other animals.

PROSAUROPOD

Early plant-eating dinosaur, which resembled the sauropods that replaced it.

PTEROSAUR

A flying reptile with wings formed from skin.

REPTILE

A cold-blooded animal with scales and a backbone that lays its eggs on land.

SANDSTONE

Rock made up of mineral fragments deposited as sediment and then compressed until hard.

SAURISCHIANS

One of the two major orders of dinosaurs. They had a reptilelike pelvis. This order includes all theropods and sauropods.

SAUROPOD

A bulky, long-necked, long-tailed, plant-eating dinosaur that walked on all four feet.

SEDIMENT

Tiny particles of sand, silt, and clay, deposited in layers by wind, water, or ice.

SPECIES

A group of animals that look the same and breed with one another to produce young.

STEGOSAUR

A large, plant-eating dinosaur with rows of bony plates running down its back and spikes on its tail.

STROMATOLITES

These structures were created in shallow, warm water by sheets of blue-green algae and trapped sediments. Fossil stromatolites are evidence of early life.

SUPERCONTINENT

An ancient landmass, such as Pangaea, containing two or more continental plates.

SYNAPSID

A mammal-like reptile whose skull has one opening on either side.

TETHYS OCEAN

A tropical ocean that separated Gondwana and Laurasia. It was eventually closed by the northward movement of Africa and India.

THEROPOD

A two-legged, meat-eating dinosaur armed with sharp teeth and claws.

TITANOSAUR

A very large, four-legged, plant-eating sauropod dinosaur.

TRIASSIC PERIOD

Period of geological time from 251 to 205 million years ago.

TYRANNOSAUR

A very large, two-legged, meat-eating dinosaur with short arms.

VERTEBRAE

The linked bones that make up the backbones of animals.

WARM-BLOODED

When an animal, such as a mammal or a bird, can control its own body temperature and keep it at a constant level.

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